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Impact of Institutional Support for Research and Development at an R1 University

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IMPACT OF INSTITUTIONAL SUPPORT FOR RESEARCH AND DEVELOPMENT AT AN R1 UNIVERSITY

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ABSTRACT

This study utilizes a correlational research design to identify the relationship, if any, between institutional and external support of research and development (R&D) at an R1 University Carnegie Classification of Institutions of Higher Education R1: Very High Research Activity Doctoral University in the southeastern United States of America. Initial analyses of institutional and external R&D expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development (HERD) Survey from 2015 through 2020 did not identify any relationships between institutionally and externally funded R&D expenditures. Additionally, initial regressions were directionally split with positive correlations in 14 fields and subfields and negative correlations in 16 fields and subfields.

As initial regressions were inconclusive, additional simple linear regressions of institutionally funded R&D expenditures from 2014 through 2019 and externally funded R&D expenditures for the following fiscal years of 2015 through 2020 were performed. Secondary data analyses utilizing a one fiscal year lag reveal relationships in two fields and four subfields as reported in the NSF HERD Survey. A majority of the secondary regressions (23 or 77%) were positive, with externally funded R&D expenditures increasing as institutionally funded R&D expenditures increased. Only seven fields and subfields, or 23%, were negatively correlated with externally funded R&D expenditures decreasing as institutionally funded R&D expenditures increased.

The study of return on investment relationships between institutional and external support of R&D was undertaken in response to a marked decline in federal support of R&D within higher

education as well as limited funding provided by other external entities including state and local governments, businesses, and non-profit entities. Regular analysis of the relationships between institutionally and externally funded R&D provides an opportunity for leaders of institutions of higher learning to maximize their return on the investment of institutional resources in support of R&D.

List of Abbreviations

AGB	Association of Governing Boards of Universities and Colleges
AVCRSP	Assistant Vice Chancellor for Research and Sponsored Programs
C&C	Communication and Communications
CPA	Certified Public Accountant
CPED	Carnegie Project on the Education Doctorate
Ed.D.	Doctor of Education
EE&C	Electrical, Electronic, and Communications
F&A	Facilities and administrative
GAS&O	Geosciences, Atmospheric Sciences, and Ocean
HERD	Higher Education Research and Development
NSF	National Science Foundation
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
R1 University	Carnegie Classification of Institutions of Higher Education R1: Very High Research Activity Doctoral University
ROI	Return on investment
RQ1	Research question 1
RQ2	Research question 2
SD&P	Sociology, Demography, and Population
SPA Manager	Manager of Sponsored Programs Accounting

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MANUSCRIPT I

Government and private industry turned to higher education institutions early in the 20th century for assistance with solving problems and developing new products, particularly those related to agricultural and industrial fields (Thelin, 2017). The level of research and development (R&D) by American universities further expanded following World War II as institutions engaged in active competition for large research grants offered by federal agencies (Thelin, 2017). External research funding from federal agencies, businesses, and non-profit entities such as foundations became an increasingly significant source of funding for R&D at educational institutions and, consequently, an essential element of institutional operating budgets separate from student tuition revenues, state appropriations, and donations (Thelin, 2017).

Today, colleges and universities continue to rely upon federal agencies, private corporations, foundations, and non-profit entities to support their organizational missions and fund their research endeavors. The Science and Engineering Indicators 2018 report issued by the National Science Foundation's National Science Board and National Center for Science and Engineering Statistics revealed from 1972 to 2016, federal agencies provided approximately 60% of all funding support for R&D performed at colleges and universities. In 2016, federal support fell to a low of 54%, with institutional, intramural funding slowly increasing from 11% in 1972 to a high of 25% of total R&D support for 2016 (National Science Foundation, 2018). State and local governments, businesses, and non-profit entities each contributed less than 10% of the total R&D support for colleges and universities in 2016 (National Science Foundation, 2018).

The reliance on external R&D funding has continually increased as public universities in the United States of America have experienced substantial reductions in state appropriation support of their general operating budgets in recent years (Huenneke et al., 2017; Picus & Odden, 2011). Oliff, Palacios, Johnson, and Leachman (2013) reported reduced funding in state-level budgets for 2013 compared to 2008 by 48 states, with 36 of those states reducing funding by more than 20%. The Science and Engineering Indicators 2018 report issued by the National Science Foundation's National Science Board and National Center for Science and Engineering Statistics reflects a decrease in state and local funding of R&D from 10.2% in 1972 to 5.6% in 2016 (National Science Foundation, 2018). These reductions place financial constraints on public institutions of higher learning leading to an overall decrease in the availability of financial resources to support operations, fund R&D, maintain affordable tuition rates, and prevent personnel actions such as furloughs and hiring freezes (Rincon & George-Jackson, 2016).

Findings from a 2018 report by the Association of Governing Boards of Universities and Colleges (AGB) further supports the analysis of R&D funding. AGB surveyed college and university board members from the public, independent non-profit, and private for-profit sectors regarding the most pressing issues facing higher education. The more than 1,000 respondents across the three sectors cited their top three concerns as all closely related to finance and higher education finance's impact upon the value and worth of a college education (AGB, 2018). Changes in state appropriation funding levels for higher education was further evidenced as 40% of AGB (2018) survey respondents from the public sector cited reductions in state funding for higher education as a primary concern for their institution.

Research Costs

Typical costs associated with research conducted by faculty and staff at colleges and universities include, but are not limited to, salaries and wages, lab and other research supplies, such as specimens and animal care charges, domestic and foreign travel to conduct research and present findings as well as publication costs. Universities fund a majority of these research costs through grants and contracts received from federal entities, state agencies, business and industry, and non-profit entities (Barr & McClellan, 2018).

Another consideration related to the R&D funding is the associated indirect cost recoveries generated by external funding sources. With the decline in federal support for R&D at American universities, research expenditures funded by institutional sources has more than doubled from 12% in the 1950s to nearly 25% by 2014 (Herman & Neuhauser, 2016). Herman and Neuhauser (2016) posit this upward trend in intuitional funding of R&D is not sustainable. Institutional funds do not generate indirect cost recovery revenues like funding from federal agencies, vital to maintaining university infrastructure and support services (Herman & Neuhauser, 2016). As an example, for the fiscal year ending June 30, 2020, the University of Mississippi has a federally negotiated indirect cost rate of 46% for organized research ("Facilities and Administrative (F&A) Cost Rates," n.d.). For every $1,000 of direct research costs funded internally rather than externally, the University of Mississippi foregoes $460 of indirect cost recovery revenues.

Although largely funded through external resources, colleges and universities must also financially support research. Institutional funds are required when external awards mandate cost-share or an institutional match to secure the external funds. Faculty and staff rely upon institutional support for initial or start-up costs incurred before securing external funding for their research. For example, an interview with John Adrian, Business Manager for Academic Affairs in the Office of the Provost, revealed a five million dollar commitment for start-up packages for recruiting research faculty at the University of Mississippi for the fiscal year 2020 (Adrian, 2019).

Return on Investment

Merriam-Webster (n.d.) defines return on investment (ROI) as a measure of "the gain or loss generated on an investment relative to the amount of money invested." The return component of the study's evaluation of ROI is the change in levels of externally funded expenditures at the university from such sources as federal entities, state agencies, business and industry, and non-profit entities relative to university investment. The investment component of this study's evaluation of ROI is a broad consideration of institutional financial resources expended in support of R&D, including general operating funds derived through student tuition and fee revenues, state appropriations, and recoveries of indirect costs. Indirect costs, or facilities and administration costs, are those costs incurred by the college or university for general operations of the institution such as utilities, facilities, and centralized services such as purchasing and accounting (Barr & McClellan, 2018).

Statement of the Problem

What is the relationship, if any, between institutional investment levels and external support of R&D that might guide university administrators in their allocation of limited financial resources? This study examines the return on investment of institutional financial support for R&D at a Carnegie Classification of Institutions of Higher Education R1: Very High Research Activity Doctoral University (R1 University). Any statistically significant relationship data identified through this study are beneficial for leveraging limited financial resources to garner external funding for institutional research endeavors.

The need for data related to ROI of institutional financial support of R&D was noted during a summer 2018 conversation with Dr. Morris Stocks, Professor and Don Jones Chair of Accountancy at the University of Mississippi, which holds the Carnegie R1 University designation. Dr. Stocks also served as the institution's Provost for nine years and served during 2015 as Acting Chancellor. I briefly shared with Dr. Stocks my interest in understanding how university administrators determine the allocation of institutional funds in support of R&D. Dr. Stocks recounted his first-hand experience as a senior-level administrator faced with many funding requests and limited resources to satisfy those requests. He expressed the need to effectively allocate institutional resources fairly and equitably, resulting in the maximization of the support provided for the various research efforts (M. Stocks, personal communication, 2018).

A fall 2018 interview with John Adrian, Business Manager for Academic Affairs in the Office of the Provost at the University of Mississippi, further supported the continued relevance and importance of allocation of institutional resources in support of R&D. I gleaned insight into how to structure a research plan by examining this emerging problem of practice qualitatively through interviewing Adrian.

The following section shares my positionality related to the focus and specific problem of practice for this study. Subsequent sections of this manuscript address the study's connection to the principles of the Carnegie Project on the Education Doctorate (CPED), the conceptual framework applied to study the impact of institutional support, and a summary of relevant literature reviewed. Concluding the manuscript is a detail of the study's methodology, the research questions to be answered, and a brief overview of subsequent manuscripts.

Positionality

As a scholar-practitioner, I acknowledge that my personal and professional background and future aspirations inherently affect my planned research on the impact of institutional support on R&D at an R1 University. This section allows me to share how my personal background, professional experience, and plans for the future shape this study.

Personal Background

The youngest of four children in a Lafayette County, Mississippi family, I was taught by my parents the importance of self-actualization. Our household did not specifically use the self-actualization term, but my parents expected each of their children to act with integrity and always do their best. We were a family with one income derived from farming supplemented by for-hire trucking and dirt work services. While my father left for work early each morning and returned home most nights after the sun went down, my mother tirelessly raised four children and managed the household's finances and operations. My mother always placed others' needs ahead of her own and strived for efficiency to make the most of available resources while planning for unforeseen circumstances. My father's strong work ethic continued into his mid-80's as he continued providing local hauling services, performing dirt work with heavy machinery, and taking care of cattle until his brief hospitalization and death from COVID-19.

Neither of my parents attended college, but they stressed the importance of education and encouraged their children to pursue an education past high school. Not only did they verbally support education, but they were also willing to provide full financial support to cover the cost of post-secondary education as an investment realizing the potential impact on their children's futures. Regardless of what path we each chose to pursue, our parents expected my older siblings and me to rise to our full potentials. Ultimately, my sister and I both obtained bachelor and master degrees from the University of Mississippi in elementary education and accounting, respectively. One of my brothers completed a two-year diesel technology training program, while my other brother elected to forego college and enter the workforce immediately upon high school graduation. Thanks to our parents' influence and example, we all are financially stable and successful in our fields of work.

Merit-based scholarships primarily covered my college education cost, which was an ROI from my high school career efforts. I changed my major program of study from pharmacy to accounting in my sophomore year. Even with this abrupt change, I was determined to graduate within four years to maximize scholarship support rather than relying on my parents to pay out-of-pocket for an additional year of college. I took more academic credit hours each semester than most of my fellow students and received bachelor and master degrees of accountancy in 1998 and 1999, respectively.

The certified public accountant (CPA) examination provided another personal ROI lesson. As someone who had been able to do well academically without developing ideal study habits, I naively sat for the CPA exam the first time in 1999 without studying. Once the examination scores were available, it became apparent that I would be required to formally prepare for the CPA examination rather than rely upon my basic knowledge. Through investing time and effort to prepare adequately, I successfully passed in 2002 and became licensed as a CPA in the State of Tennessee and later obtained a reciprocal CPA license from Mississippi.

Through my familial and educational shaped views, I present a primary assumption of this study that one should have something to show or intangible benefits achieved from the investment of time and financial resources. This central assumption underlying the study is that one must appropriately allocate resources and ensure reasonable efforts to maximize benefits derived. Institutional support provided should not be used merely as a tool for the enticement of employment acceptance for prospective faculty and researchers at the university but as an investment with measurable returns.

Professional Experience

After graduation in 1999, I worked for approximately twelve years in public accounting specializing in assurance services. As an auditor, I saw first-hand how the effective allocation of resources can impact an entity's daily operations and long-term financial stability. In 2011, I joined the University of Mississippi as the Manager of Sponsored Programs Accounting (SPA Manager), which was a new position created and funded by the Offices of Accounting and Research and Sponsored Programs. The SPA Manager position was an investment of resources aimed at improving cohesiveness between the two offices to manage post-award fiscal administration of contracts and grants. The position was created based on an identified need with expected results. The SPA Manager position and other positions across campus are similarly established and maintained based on identified needs and expected responsibilities or ROI achieved through these roles.

In the SPA Manager position, I first encountered the concept of start-up funding offered to new faculty and researchers and its related benefits within higher education. As part of my duties as the SPA Manager, I was responsible for reconciling start-up funding commitments from central funds, the dean, and the department. The Assistant Vice Chancellor for Research and Sponsored Programs (AVCRSP) used the reconciliation to monitor start-up fund obligations. The Office of the Provost now manages centrally sourced start-up funds in conjunction with the Office of Research and Sponsored Programs.

In 2013, I was asked to serve as the University of Mississippi's Interim Director of Accounting and permanently assumed the position in 2015. As Director of Accounting, my responsibilities related to start-up funding include review and approval of adjusting entries and closeout of accounts within the financial accounting system. My background and prior experience as an auditor make me acutely aware of the amounts and nature of charges made through start-up funds. I do not presume to understand the complexities of R&D within the various schools and departments. However, I remain ever cognizant as to the best stewardship of all University of Mississippi funds.

After eight years in financial management roles at the University of Mississippi, I have developed inherent assumptions that impact this study. Based on my experiences, start-up funds are not always timely expended. I suspect some faculty and researchers reserve those funds for use in the future as a sort of savings account. Additionally, I assume start-up funding levels can be somewhat arbitrary to increase the attractiveness of hiring packages rather than derived from a projection of obtaining external funding or costs to be incurred for the purpose for which they are established, namely the support of research conducted by those newly hired.

Future Plans

As a native resident of Lafayette County with strong personal ties to the area, I plan to continue working at the University of Mississippi until my retirement. I want my years of service to positively impact processes and improve operational efficiencies to continue producing high-caliber research and ultimately better serve the University of Mississippi student population.

Carnegie Project on the Education Doctorate

This study is completed as part of the University of Mississippi's Doctor of Education (Ed.D.) with an emphasis in Higher Education program requirements. The program is affiliated with the Carnegie Project on the Education Doctorate (CPED) ("Higher Education," n.d.). The CPED focuses on how to structure research and address problems of practice for institutions of higher learning within a framework of equity, ethics, and social justice ("The Framework," n.d.). This study of the impact of institutional support of R&D incorporates these three tenets in examining the return on investment of institutional financial support of R&D at an R1 University.

Conceptual Framework

Just as a blueprint serves as the guide for constructing a home, a conceptual framework serves as the guide for a research study outlining the statement of problem, purpose, significance, and questions (Grant & Osanloo, 2014). Return on investment and relationship modeling as described further within this section comprise the study's conceptual framework for analyzing relationships between institutional and external financial support of R&D at an R1 University and are addressed within this section.

Return on Investment

Colleges and universities often assume corporate or management characteristics in an attempt to maximize economic benefits resulting from the performance of research addressing public needs through a neoliberal managerialism perspective of R&D (Deem, Hillyard, & Reed, 2007). A quintessential example of this perspective is the utilization of ROI calculations as a key indicator of performance analysis and decision making when assessing the gain or loss resulting from a given investment or action (Zamfir, Manea & Ionescu, 2016). Zamfir, Manea, and Ionescu (2016) share that conventional ROI is calculated as the percentage ratio between the return divided by the investment, with the result being multiplied by 100. For this study's examination of the ROI of institutional financial support for R&D at an R1 University, the denominator investment amount is R&D expenditures paid from general and institutionally designated financial resources, with the numerator return amount being externally funded R&D expenditures.

Relationship Modeling

In her study "Does External Funding of Academic Research Crowd Out Institutional Support" in the *Journal of Public Economics,* Connolly (1997) states, "Much effort is devoted to attracting external research support at U.S. universities, but the influence of the level of internal support on the success of this effort is poorly understood" (p. 391). Connolly (1997) posits two criteria must be met to consider funding as external: (a) funding must originate outside the university, and (b) the external agency, whether a federal agency, corporation, or non-profit entity, must designate such funds for scientific research effectively prohibiting the university from allocating the funds for any other uses. Similarly, Connolly (1997) provides two criteria for classifying funds as internal: (a) funds must come from financial resources pools that are not restricted and used by the university in any manner regardless of the source of the funds, and (b) the university must budget the funds for research.

Connolly (1997) shares an overview of two approaches for modeling relationships between institutional and externally sponsored research. The first is a static utility-maximization model in which institutions of higher education value other activities in addition to research and strive for equilibrium among all activities (Connolly, 1997). Under the static utility-maximization model, universities allocate institutional funds to other activities when there are increases in funding from external sources (Connolly, 1997). Connolly (1997) concludes that external support crowds out, or replaces, internal support of research under this model. The second approach Connolly (1997) discusses is a variation of the static utility-maximization model, which "allows for joint costs of production between research and nonresearch activities. . . . [which] can reverse the predicted sign of the relationship but only if there are strong diseconomies of scope between research and other activities" (p. 392-393). Connolly (1997) states that when both research and other university activities are complements, there continues to be evidence of partial supplanting, or crowding out, of internal support for research.

Connolly (1997) indicates that a static model such as these two previously discussed cannot adequately predict the existence and direction of causational relationships and uses Holtz-Eakin et al.'s (1988) extension of vector autoregression techniques in her investigation of the relationship between internal and external funding of academic research. In her study, Connolly (1997) examined an extended time period to account for changes in research quality and intensity as well as macroeconomic influences. Similar to my proposed research, Connolly (1997) utilized data compiled by the National Science Foundation from 1979 through 1990 in her study of 195 universities. Connolly (1997) finds there is no crowding out or a reduction in funding from external sources caused by an increase in internal sources and reveals three significant findings of (a) a positive relationship between both sources of funding levels, (b) causality runs in both directions between sources, and (c) one-time changes of either source can last for several years.

This study will use as a variation of Connolly's approach in utilizing the National Science Foundation's (NSF) Higher Education Research and Development (HERD) Survey data over ten years for statistical analysis. My research seeks to identify whether there is a positive return on investment achieved through increased external funding of R&D based on varying institutional support levels at an R1 University.

Literature Review

This section presents select literature relevant to the study. Specifically, it offers an overview of literature related to both research and development and literature on the Research 1 Carnegie classification.

Research and Development

The NSF HERD Survey serves as the primary annual reporting source of R&D expenditures for colleges and universities in the United States of America (Higher Education Research and Development Survey, n.d.). The NSF HERD Survey defines R&D as "creative and systematic work undertaken in order to increase the stock of knowledge, including knowledge of humankind, culture, and society, and to devise new applications of available knowledge" (Higher Education Research and Development Survey, n.d.). This definition used by the NSF for the HERD Survey is based upon the Organisation for Economic Co-operation and Development's (OECD) definition and guidance. The OECD posits an R&D activity must be: (a) novel, (b) creative, (c) uncertain in its outcome, (d) systematic, and (e) transferable and/or reproducible (Definitions of Research and Development, 2018). The NSF and OECD further outline three types of R&D as: (a) basic, (b) applied, and (c) experimental development (Definitions of Research and Development, 2018).

Survey respondents report expenditures by external or internal funding sources for R&D fields and subfields. External sources of funds include the U.S. federal government, further detailed by major federal agencies, state and local governments, businesses, nonprofit organizations, and other external sources such as foreign entities. Internal sources of funds include institutional direct financial support of R&D, matching or cost-share funds required as part of externally funded awards, and unrecovered indirect costs. Unrecovered indirect costs result from external entity award budgets which do not allow an institution to recover indirect facilities and administrative costs at their federally negotiated rate. The difference between the award budget's indirect cost rate allowed and the negotiated indirect cost rate is reported as part of the institutional R&D expenditures.

Basic Research

Basic research is performed primarily to acquire new knowledge without an intended application or use (Definitions of Research and Development, 2018). The NSF HERD Survey (n.d.) provides the following examples of basic research:

1. "A researcher is studying the properties of human blood to determine what affects coagulation."
2. "A researcher is studying the properties of molecules under various heat and cold conditions."
3. "A researcher is investigating the effect of different types of manipulatives on the way first graders learn mathematical strategy by changing manipulatives and then measuring what students have learned through standardized instruments."

Applied Research

Applied research is similar to basic research in that it is performed to acquire new knowledge (Higher Education Research and Development Survey, n.d.). However, it differs from basic research as applied research is "directed primarily towards a specific, practical aim or objective" (Definitions of Research and Development, 2018). The NSF HERD Survey (n.d.) provides the following examples of applied research:

1. "A researcher is conducting research on how a new chickenpox vaccine affects blood coagulation."
2. "A researcher is investigating the properties of particular substances under various heat and cold conditions with the objective of finding longer-lasting components for highway pavement."
3. "A researcher is studying the implementation of a specific math curriculum to determine what teachers needed to know to implement the curriculum successfully."

Experimental Development

The NSF HERD Survey (n.d.) defines experimental development research as "Systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes." The NSF HERD Survey (n.d.) provides the following examples of experimental development research:

1. "A researcher is conducting clinical trials to test a newly developed chickenpox vaccine for young children."
2. "A researcher is working with state transportation officials to conduct tests of a newly developed highway pavement under various types of heat and cold conditions."
3. "A researcher is developing and testing software and support tools, based on fieldwork, to improve mathematics cognition for student special education."

R1 University Carnegie Classification

The Carnegie Classification of Institutions of Higher Education system provides a framework of comparable category groupings for American colleges and universities utilizing results of surveys conducted by the National Science Foundation related to research and development, graduate students and postdoctorates in science as well as engineering and data collected through the Integrated Postsecondary Education Data System (Indiana University Center for Postsecondary Research, n.d.). Institutions are assigned into one of six classifications: (a) doctoral universities, (b) master's colleges and universities, (c) baccalaureate colleges, (d) baccalaureate/associates colleges, (e) special focus institutions, or (f) tribal colleges (Indiana University Center for Postsecondary Research, n.d.). The most prestigious designation, R1: Doctoral University – Very High Research Activity, is assigned to those institutions that "awarded at least 20 research/scholarship doctoral degrees and had at least $5 million in total research expenditures" (Indiana University Center for Postsecondary Research, n.d.).

Methodology

Cresswell and Guetterman (2019) posit that it is important to "relate your approach to your personal experience and training" (p. 20). A quantitative research approach is best suited for identifying trends (Cresswell & Guetterman, 2019) and aligns well with my experience as an accountant accustomed to analyzing financial data. The following sections provide an overview of the planned research design, procedures, and analyses for this study of the ROI of institutional financial support for R&D at an R1 University.

Research Design

This study utilizes a correlational research design in obtaining an understanding of what relationship, if any, exists between institutional and external funding sources of the university's R&D expenditures. "Correlational designs are procedures in quantitative research in which investigators measure the degree of association (or relation) between two or more variables using the statistical procedure of correlational analysis" (Cresswell & Guetterman, 2019, p. 21). Identifying whether positive or negative correlations exist between internal and external funding of R&D provides credible evidence in support of allocation decisions for college and university administrators.

Financial indicators include all R&D expenditures funded externally as compared to those funded institutionally by the university. The study's independent variable is the amount of institutional support provided for R&D. The study's dependent variable is the amount of R&D expenditures funded through external sources.

Procedure and Analysis

The study will employ statistical analysis of data for an R1 University in the southeastern United States of America over ten years. First, a simple linear regression analysis will be conducted utilizing two continuous variables for the annual amounts of externally funded and institutionally funded R&D expenditures from July 1, 2009, through June 30, 2019, as extracted from reported NSF HERD Survey results. An alpha level of .05 will be utilized with descriptive statistics reported in a table format for the initial data analysis. Further statistical analyses will be performed on the extracted data to identify whether results are consistent across all schools and departments for the university. Simple linear regressions will be conducted for each school and department for each of the fiscal years.

The effect size, identified as R^2, will be calculated and reviewed to determine the strength of the percentage of variances among the variables accounted for in the model if statistical significance is found to be present. An R^2 ranging from 0.13 to 0.25 would indicate a moderate effect size with small and large effect sizes falling below and above, respectively, the mid-range of values (Dimitrov, 2013).

Research Questions

The research questions directing the study of the return on investment of institutional financial support for R&D at an R1 University are stated below, including the associated null and directional alternative hypotheses. A null hypothesis predicts no existing relationships between independent and dependent variables studied (Cresswell & Guetterman, 2019). Directional alternative hypotheses predict a relationship that, as the independent variable increases or decreases, the dependent variable correspondingly increases or decreases (Cresswell & Guetterman, 2019).

Research Question 1 (RQ1)

How, if at all, does the amount of institutional financial support relate to externally supported R&D expenditures at an R1 university?

Null Hypothesis RQ1

The Null Hypothesis for RQ1 states that there is no relationship between total R&D expenditures funded by external sources and total R&D expenditures funded by an R1 university.

Directional Alternative Hypothesis RQ1

The Directional Alternative Hypothesis for RQ1 states that R&D expenditures funded by external sources will increase when R&D expenditures funded by an R1 university increase.

Research Question 2 (RQ2)

If any relationship exists, how, if at all, does the relationship vary across R&D fields at an R1 university?

Null Hypothesis RQ2

The Null Hypothesis for RQ2 states that there is no variance in the relationship across R&D fields.

Conclusion

As a higher education administrator at the University of Mississippi in the central Office of Accounting, I want to identify and mitigate student learning barriers stemming from a lack of financial resources. One example of such a barrier to student learning is the lack of funding to move away from large, lecture-style courses often taught by adjunct faculty to smaller class sizes and changes to physical structures of classrooms permitting small group activities. The enabling of learner-centered approaches to instruction rather than traditional teacher-centered methods has been shown to increase student learning outcomes (Ültanir, 2012). I desire to positively impact student learning outcomes and improve students' affordability and access by identifying institutional opportunities for efficient stewardship of funds. The goal of my research is to provide results leading to data-informed decisions concerning the allocation of financial resources and the resulting related impact on overall levels of R&D by administrators, both institution-wide such as the Vice Chancellors for Administration and Finance and Research and Sponsored Programs and at the school or department levels such as deans and chairs.

This manuscript has introduced my dissertation in practice's subject matter and conveyed the statement of the problem for the study. Following the statement of the problem, I shared my positionality as a researcher through a summary of my personal background, professional experience, and plans for the future. This manuscript also includes a description of the CPED principles and provides a review of relevant literature. An overview of the study's methodology, including research design, procedures to be performed, analyses to be conducted, and research question to be answered, conclude this manuscript.

This manuscript is the first of three for my dissertation-in-practice. The second manuscript will present data and analyses. The third and final manuscript will discuss the meaning of the data gathered as summarized in manuscript two, suggest the implementation of findings, and provide recommendations for further research to be performed related to the problem of practice.

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MANUSCRIPT II

The preceding manuscript introduces the subject matter or my dissertation, states the problem of practice, provides my personal and professional positionality as a researcher, and includes the guiding Carnegie Project on the Education Doctorate (CPED) ("Higher Education," n.d.) principles for my study. The first manuscript also presents relevant literature and an overview of the study's methodology. This second manuscript presents data and analyses to examine my study's problem of practice as to the existence of relationships, if any, between institutionally and externally funded research and development (R&D) expenditures. Study findings could provide insight into how to increase R&D external funding through leveraging the allocation of financial resources to increase the institution's return on investment. The final manuscript addresses the meaning of data findings, study limitations, and recommendations for research and practice.

Initial Data Analyses

I conducted simple linear regressions of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for a Carnegie R1 university located in the southeastern United States of America as reported in the National Science Foundation's Higher Education Research and Development (NSF HERD) survey for 2015 through 2020 (National Science Foundation, n.d.). An alpha level of .05 was utilized. Descriptive statistics of externally and institutionally funded R&D expenditures shown as thousands of dollars, the mean (*M*), and standard deviation (*SD*) are reported in tables with scatterplots and standardized residuals reflected in figures for each field and subfield as categorized in the NSF HERD survey. Fields and subfields with less than six fiscal years of data were excluded from analysis.

Computer and Information Sciences

Table 2.1 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Computer and Information Sciences R&D expenditures. Figure 2.1 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Computer and Information Sciences field reflecting a negative correlation where externally funded R&D expenditures decrease as institutionally funded R&D expenditures increase. Externally funded R&D expenditures shown in Figure 2.2 were somewhat normally distributed as half of the values fall closely along the line. Standardized residuals, an indicator of the strength between observed and expected values (Dimitrov, 2013), were not normally distributed as shown in Figure 2.3. Scatterplots in Figure 2.4 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity where there is a pattern between the variables (Allen, 2017) was evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the field of Computer and Information Sciences, $F(1,4) = 7.34$, $p = .054$. A large effect size, a quantitative measure of the relationship between the predictor and criterion variables (Dimitrov, 2013), was noted with approximately 64.7% of the variances accounted for in the model, $R^2 = .647$.

Table 2.1

Descriptive Statistics for Computer and Information Sciences (n = 6 and r = -0.81)

	R&D Expenditures (Dollars in thousands)	
Fiscal Year	Externally Funded	Institutionally Funded
2015	163	85
2016	88	516
2017	103	96
2018	53	551
2019	46	538
2020	101	106
M	92.33	315.33
SD	42.18	240.98

Figure 2.1

Scatter Plot of External by Institutional for Computer and Information Sciences

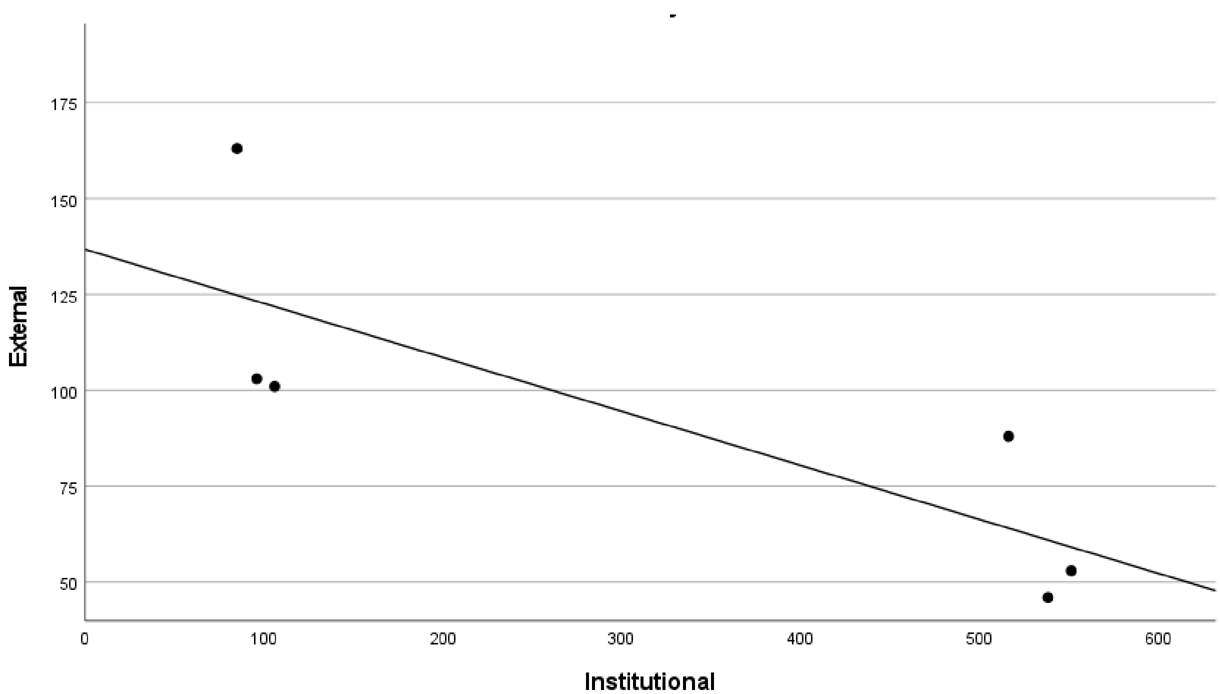


Figure 2.2

Normal Q-Q Plot of External for Computer and Information Sciences

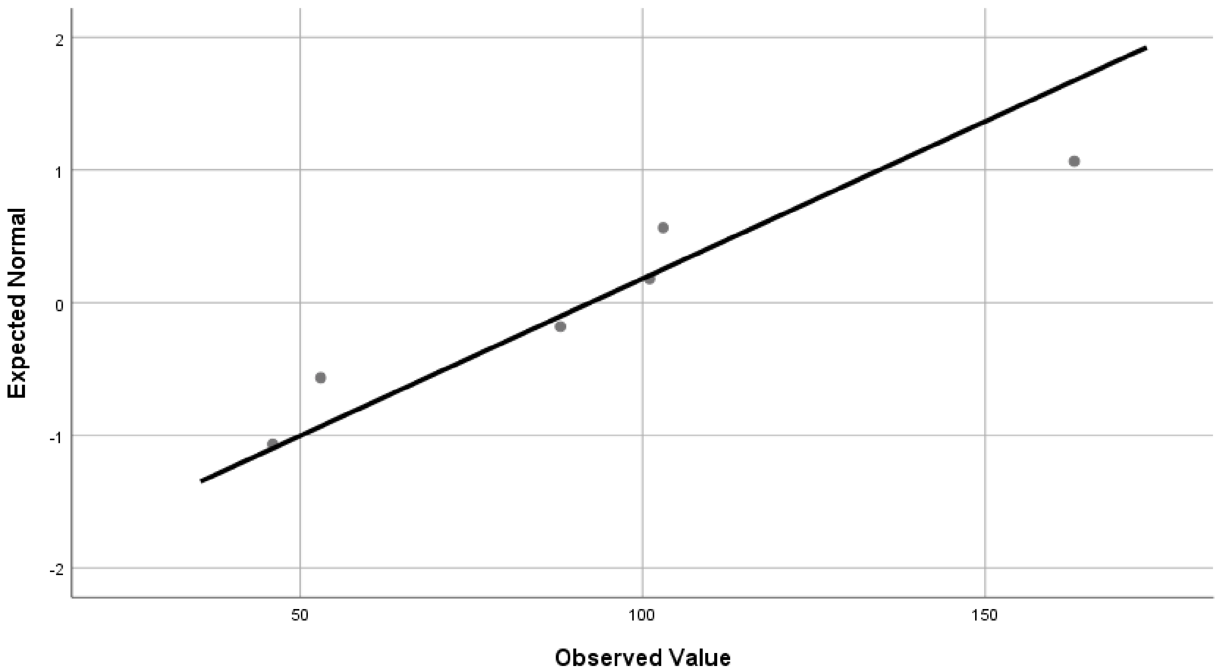


Figure 2.3

Normal P-P Plot of Regression Standardized Residual for Computer and Information Sciences

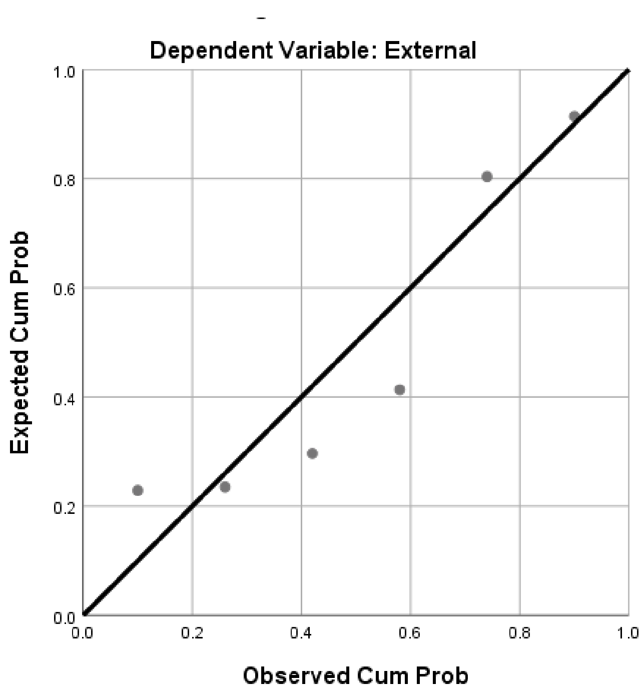
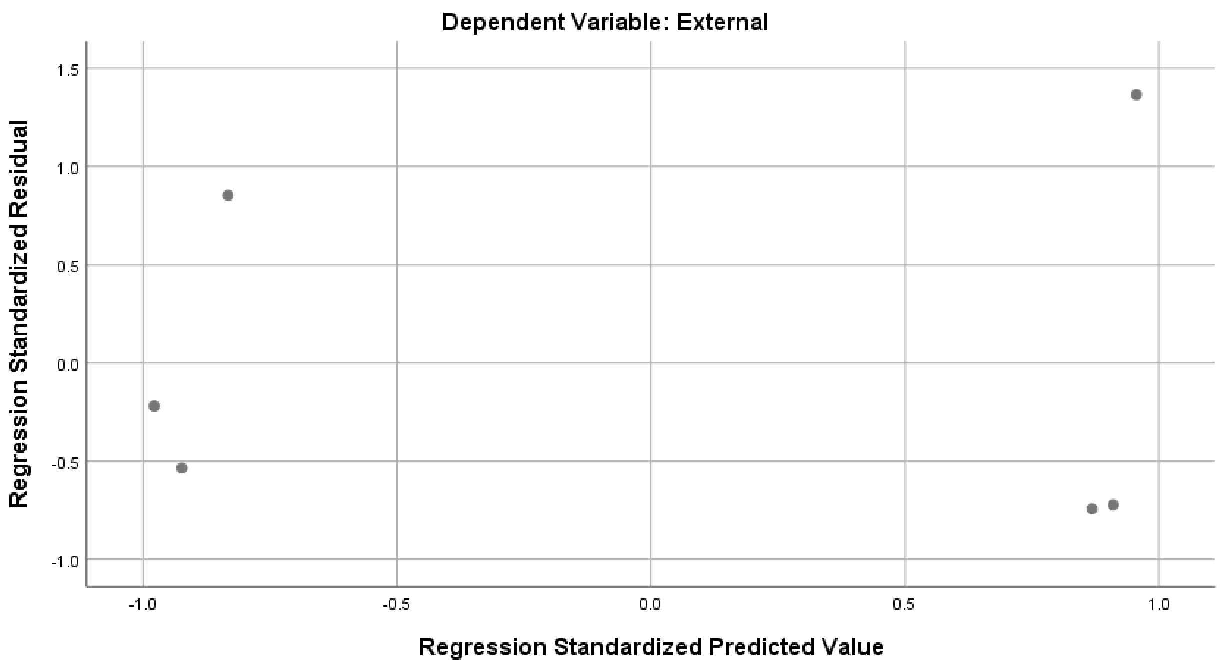


Figure 2.4

Scatterplot for Computer and Information Sciences



Engineering

Table 2.2 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Engineering R&D expenditures. Figure 2.5 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Engineering field reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.6. Standardized residuals were normally distributed as shown in Figure 2.7 as most values fall closely along the line. Scatterplots in Figure 2.8 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the field of Engineering, $F(1,4) = 2.31$, $p = .203$. A large effect size was noted with approximately 36.6% of the variances accounted for in the model, $R^2 = .366$.

Table 2.2

Descriptive Statistics for Engineering (n = 6 and r = -0.61)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	4055	1621
2016	3338	3308
2017	2740	4507
2018	3298	2164
2019	4864	3957
2020	12499	1162
M	5132.33	2786.50
SD	3682.61	1340.68

Figure 2.5

Scatter Plot of External by Institutional for Engineering

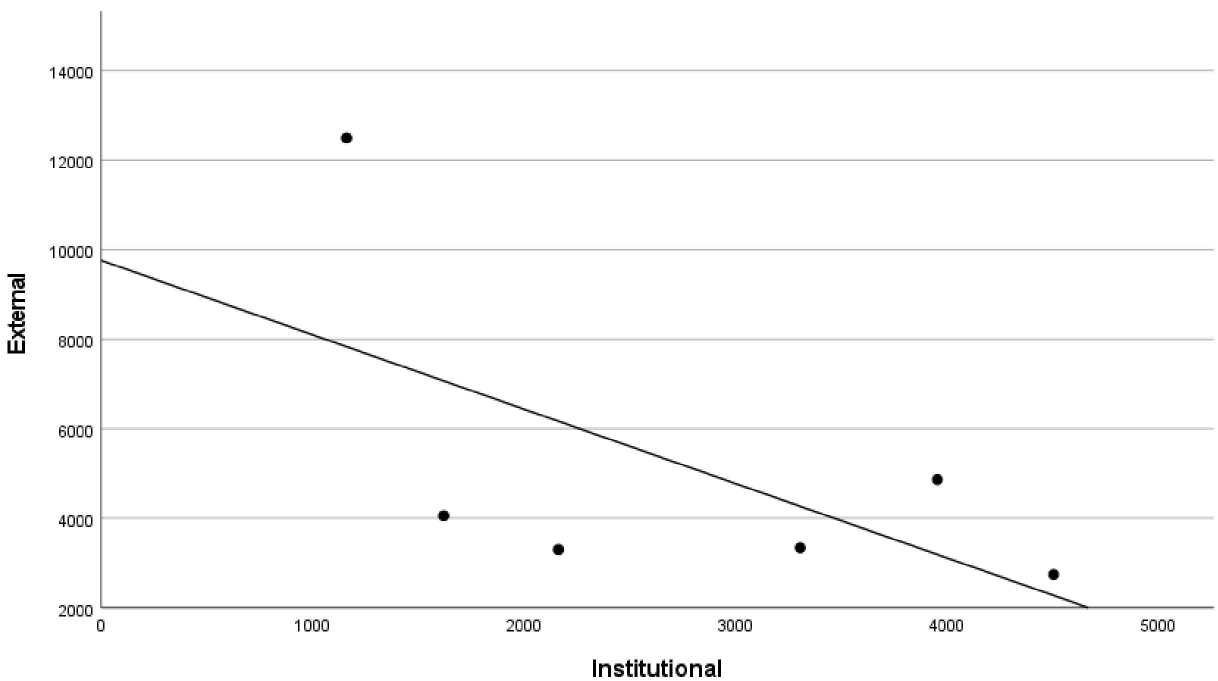


Figure 2.6

Normal Q-Q Plot of External for Engineering

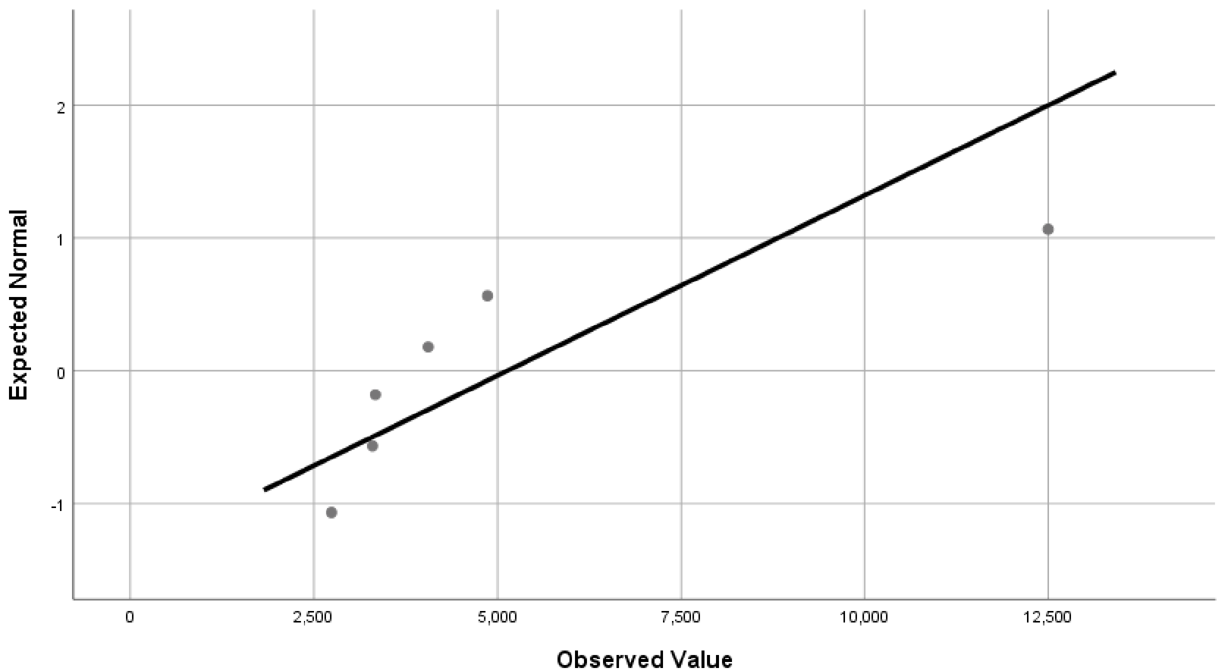


Figure 2.7

Normal P-P Plot of Regression Standardized Residual for Engineering

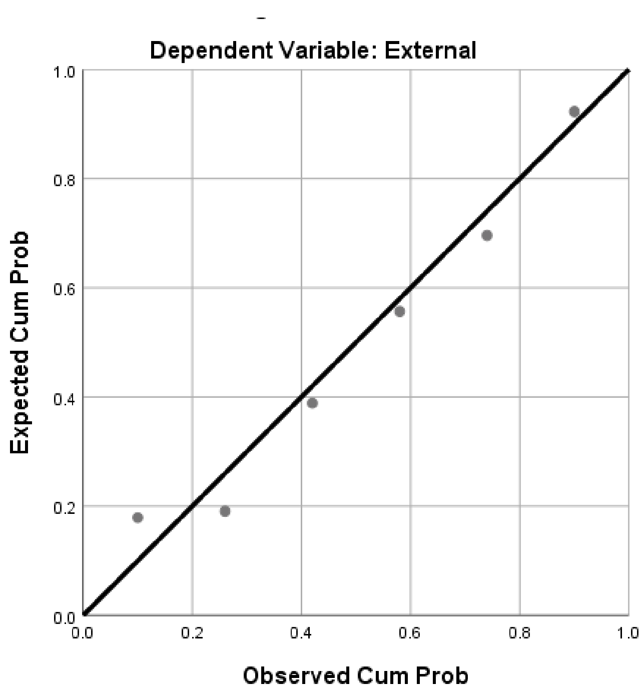
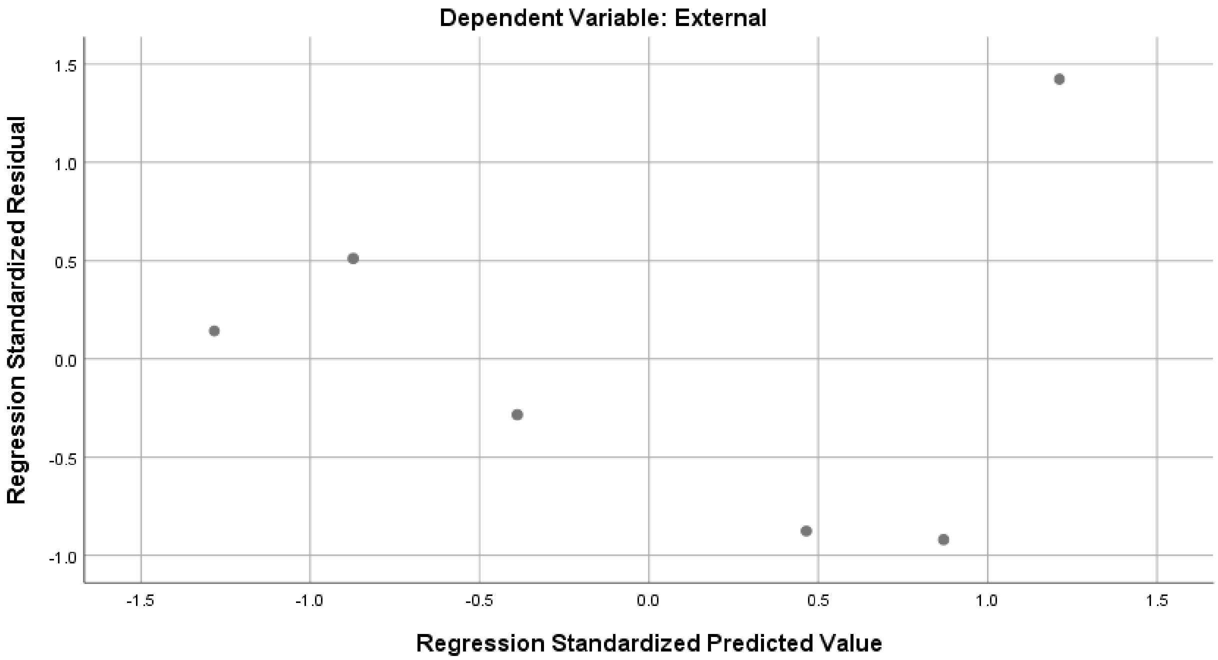


Figure 2.8

Scatterplot for Engineering



Chemical Engineering

Table 2.3 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Chemical Engineering R&D expenditures. Figure 2.9 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Chemical Engineering subfield reflecting a positive correlation where externally funded R&D expenditures increase as institutionally funded R&D expenditures increase. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.10. Standardized residuals were not normally distributed as shown in Figure 2.11. Scatterplots in Figure 2.12 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D

expenditures in the Chemical Engineering subfield, $F(1,4) = .19$, $p = .683$. A small effect size was noted with approximately 4.6% of the variances accounted for in the model, $R^2 = .046$.

Table 2.3

Descriptive Statistics for Chemical Engineering (n = 6 and r = 0.22)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	1251	260
2016	1127	802
2017	990	1944
2018	1066	379
2019	1142	1114
2020	496	161
M	1012.00	776.67
SD	267.17	675.46

Figure 2.9

Scatter Plot of External by Institutional for Chemical Engineering

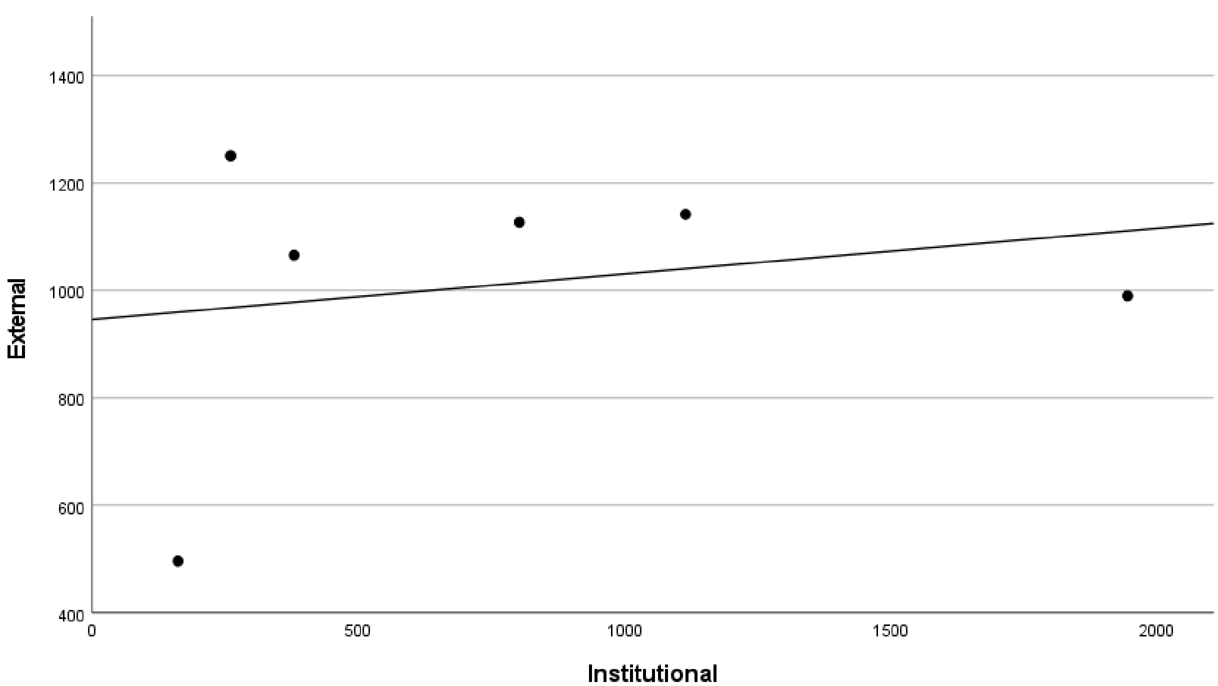


Figure 2.10

Normal Q-Q Plot of External for Chemical Engineering

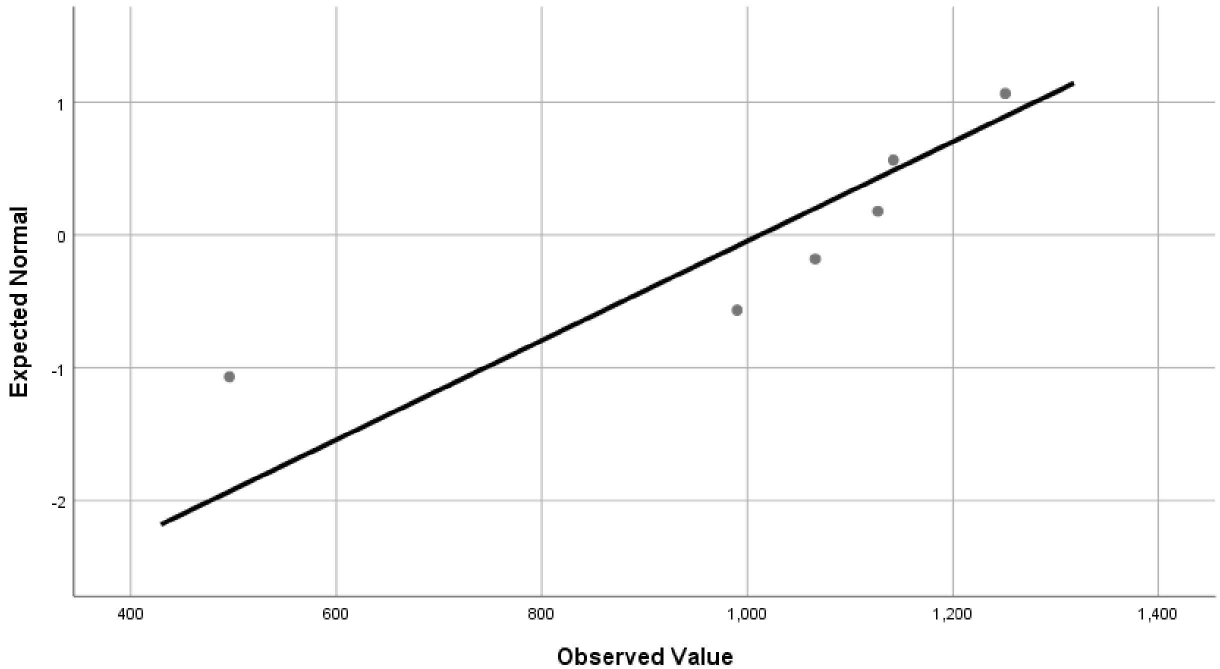


Figure 2.11

Normal P-P Plot of Regression Standardized Residual for Chemical Engineering

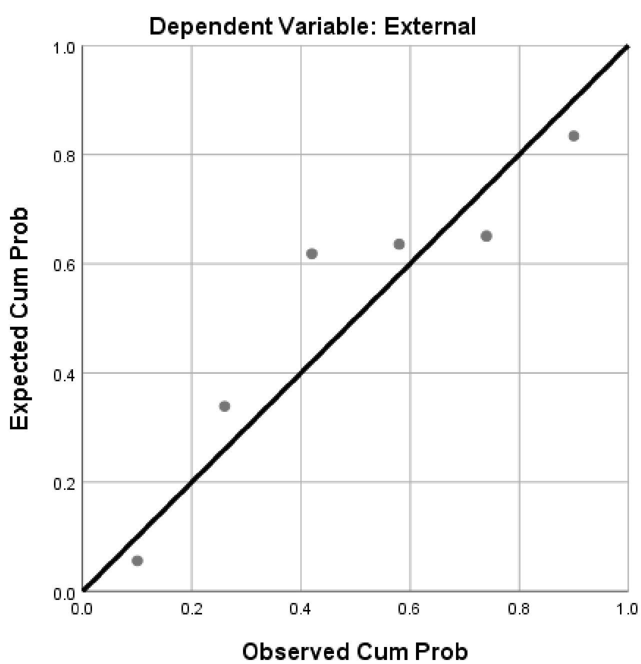
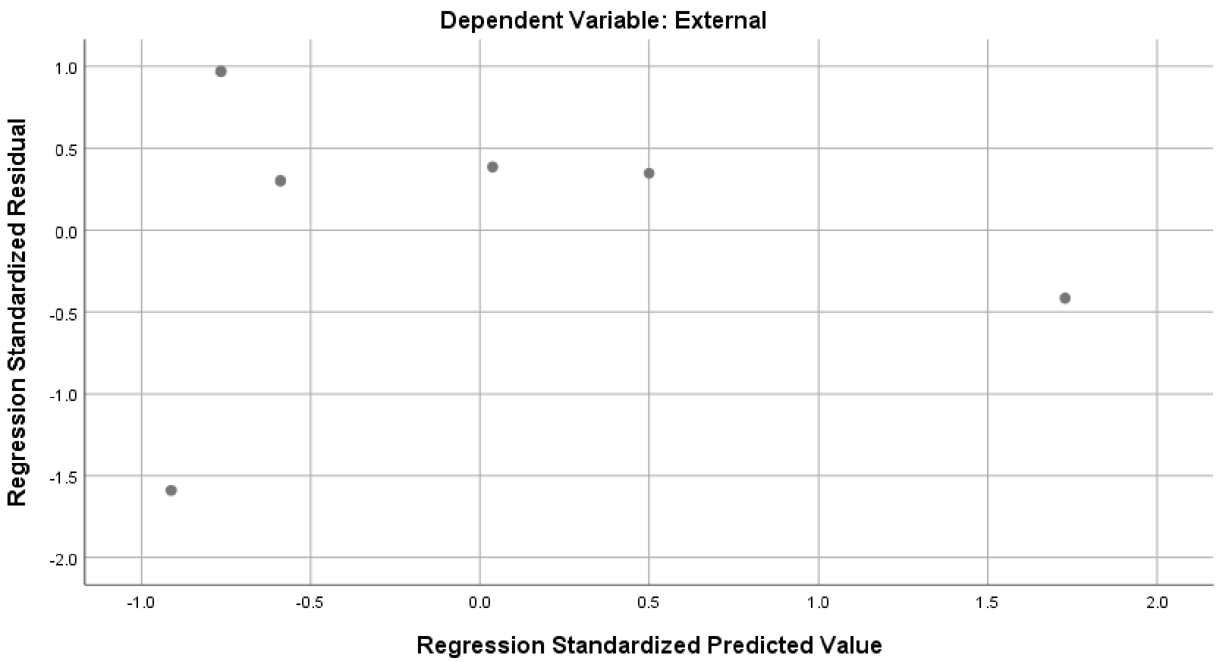


Figure 2.12

Scatterplot for Chemical Engineering



Civil Engineering

Table 2.4 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Civil Engineering R&D expenditures. Figure 2.13 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Civil Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.14. Standardized residuals were not normally distributed as shown in Figure 2.15. Scatterplots in Figure 2.16 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Civil Engineering subfield, $F(1,4) = .09$, $p = .783$. A small effect size was noted with approximately 2.1% of the variances accounted for in the model, $R^2 = .021$.

Table 2.4

Descriptive Statistics for Civil Engineering (n = 6 and r = -0.15)

	R&D Expenditures (Dollars in thousands)	
Fiscal Year	Externally Funded	Institutionally Funded
2015	373	59
2016	176	580
2017	78	427
2018	112	73
2019	345	944
2020	573	119
M	276.17	367.00
SD	188.93	353.47

Figure 2.13

Scatter Plot of External by Institutional for Civil Engineering

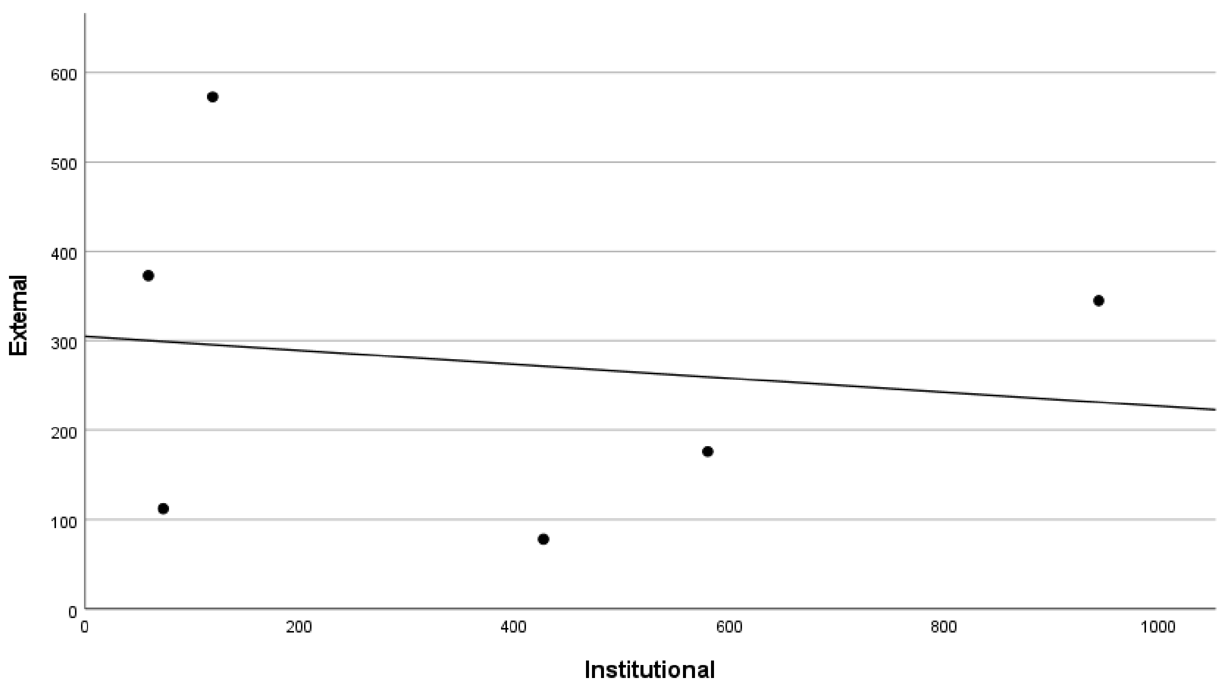


Figure 2.14

Normal Q-Q Plot of External for Civil Engineering

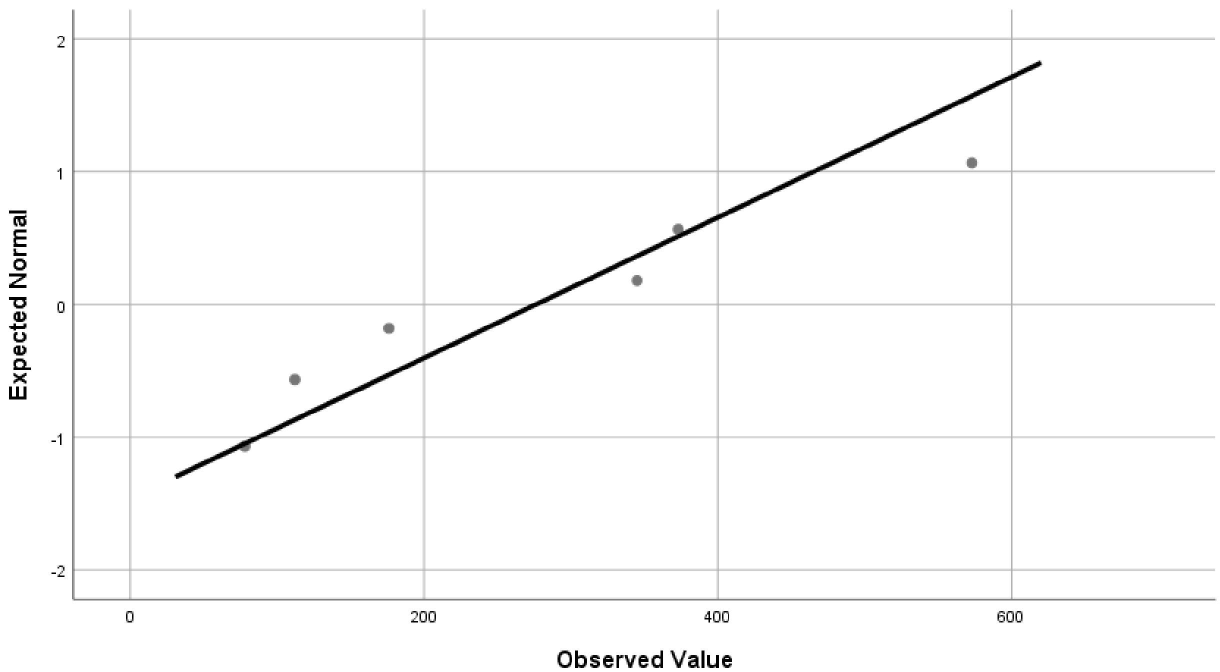


Figure 2.15

Normal P-P Plot of Regression Standardized Residual for Civil Engineering

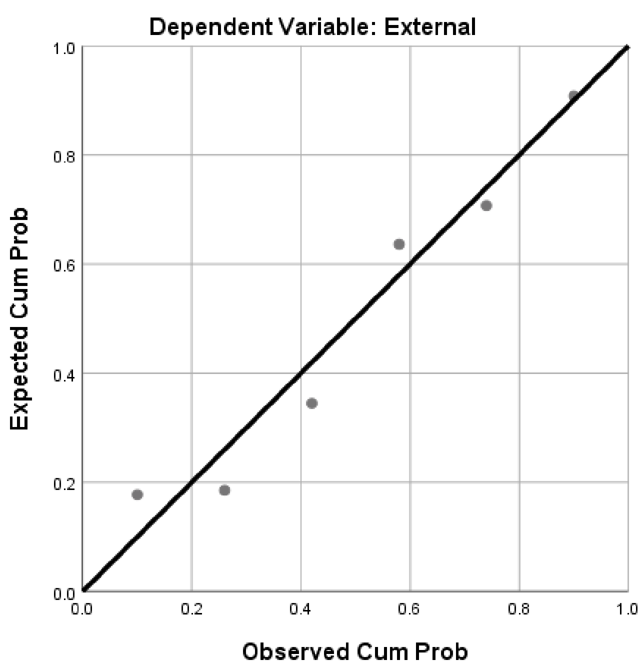
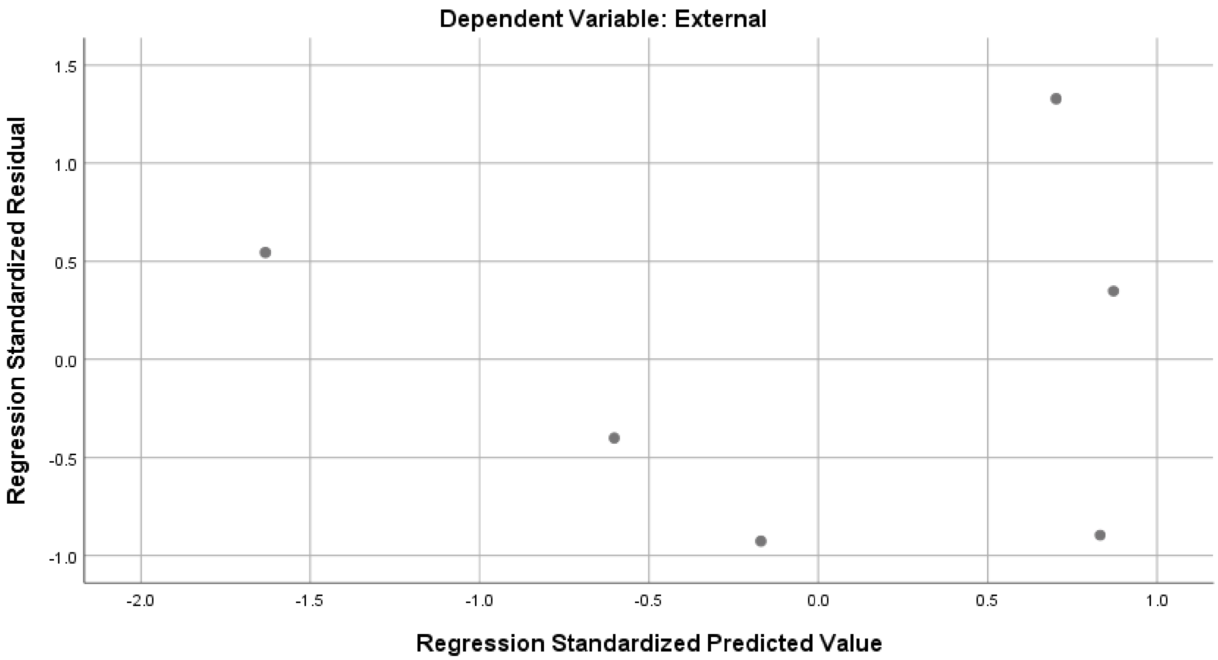


Figure 2.16

Scatterplot for Civil Engineering



Electrical, Electronic, and Communications Engineering

Table 2.5 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Electrical, Electronic, and Communications (EE&C) Engineering R&D expenditures. Figure 2.17 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Electrical, Electronic, and Communications Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.18. Standardized residuals were not normally distributed as shown in Figure 2.19. Scatterplots in Figure 2.20 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Electrical, Electronic, and Communications Engineering subfield, $F(1,4) = .77$, $p = .431$. A medium effect size was noted with approximately 16.0% of the variances accounted for in the model, R^2 = .160.

Table 2.5

Descriptive Statistics for EE&C Engineering (n = 6 and r = -0.40)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	9	71
2016	70	743
2017	223	724
2018	325	633
2019	354	840
2020	1479	149
M	410.00	526.67
SD	541.20	330.30

Figure 2.17

Scatter Plot of External by Institutional for EE&C Engineering

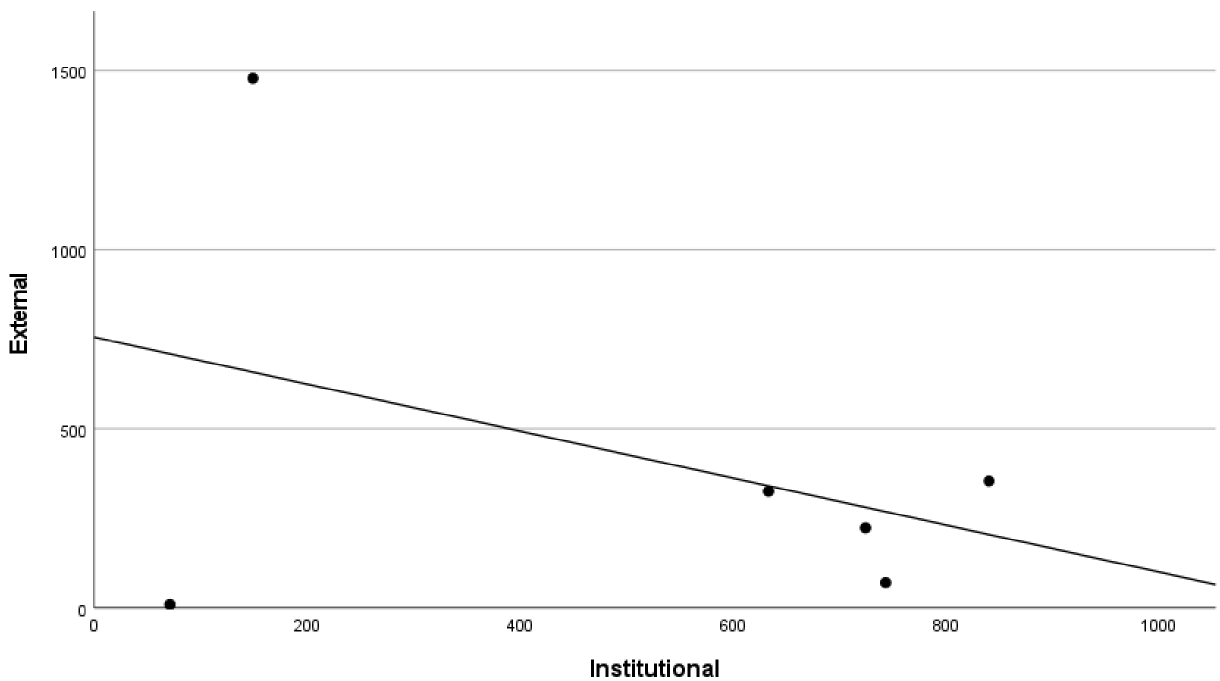


Figure 2.18

Normal Q-Q Plot of External for EE&C Engineering

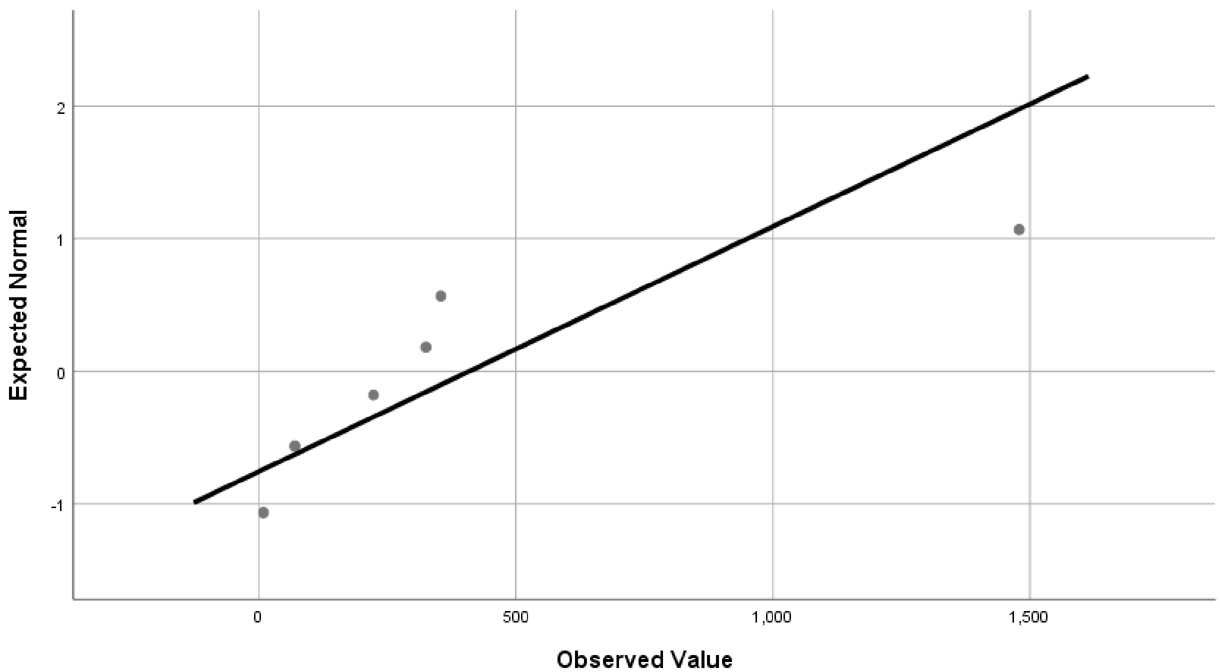


Figure 2.19

Normal P-P Plot of Regression Standardized Residual for EE&C Engineering

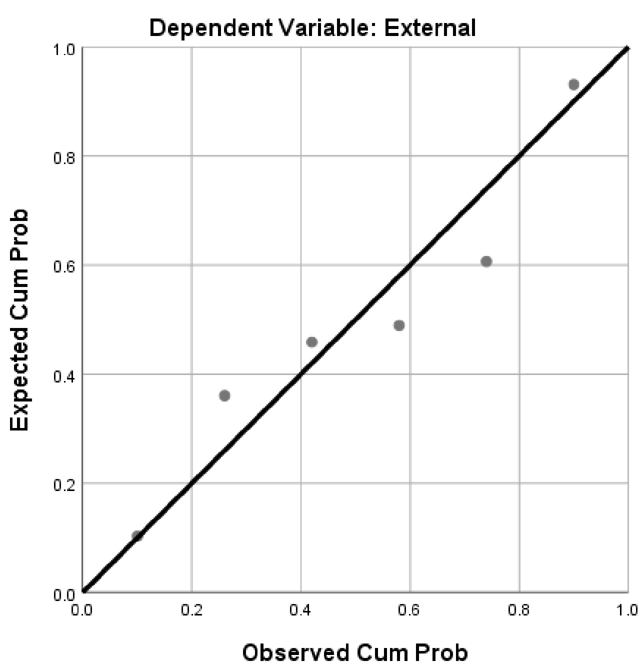
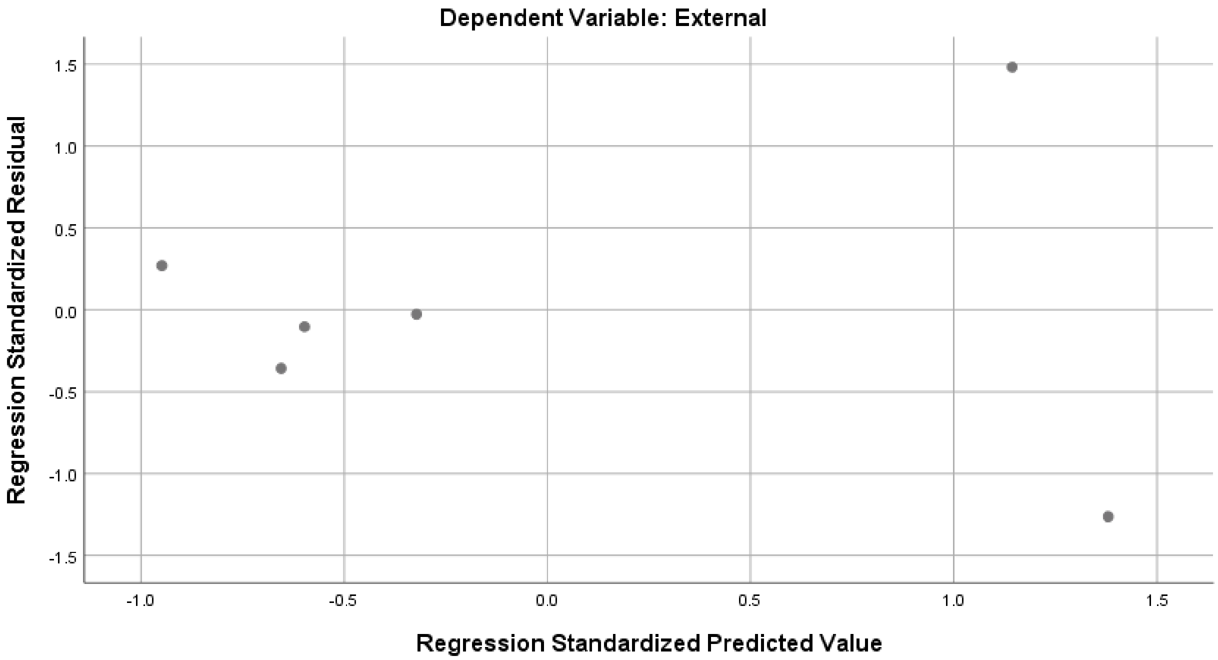


Figure 2.20

Scatterplot for EE&C Engineering



Mechanical Engineering

Table 2.6 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Mechanical Engineering R&D expenditures. Figure 2.21 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Mechanical Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.22. Standardized residuals were not normally distributed as shown in Figure 2.23. Scatterplots in Figure 2.24 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Mechanical Engineering subfield, $F(1,4) = 4.12$, $p = .112$. A large effect size was noted with approximately 50.8% of the variances accounted for in the model, $R^2 = 0.508$.

Table 2.6

Descriptive Statistics for Mechanical Engineering (n = 6 and r = -0.71)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	606	509
2016	340	715
2017	394	673
2018	155	595
2019	458	818
2020	800	112
M	458.83	570.33
SD	223.02	247.89

Figure 2.21

Scatter Plot of External by Institutional for Mechanical Engineering

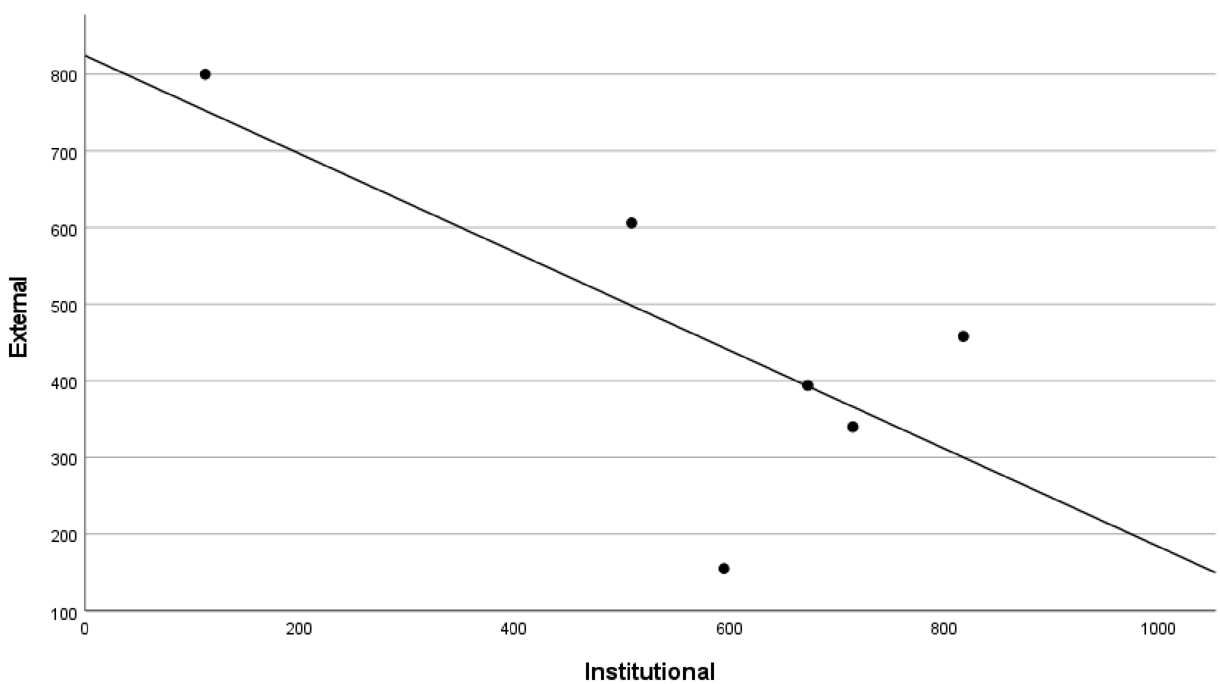


Figure 2.22

Normal Q-Q Plot of External for Mechanical Engineering

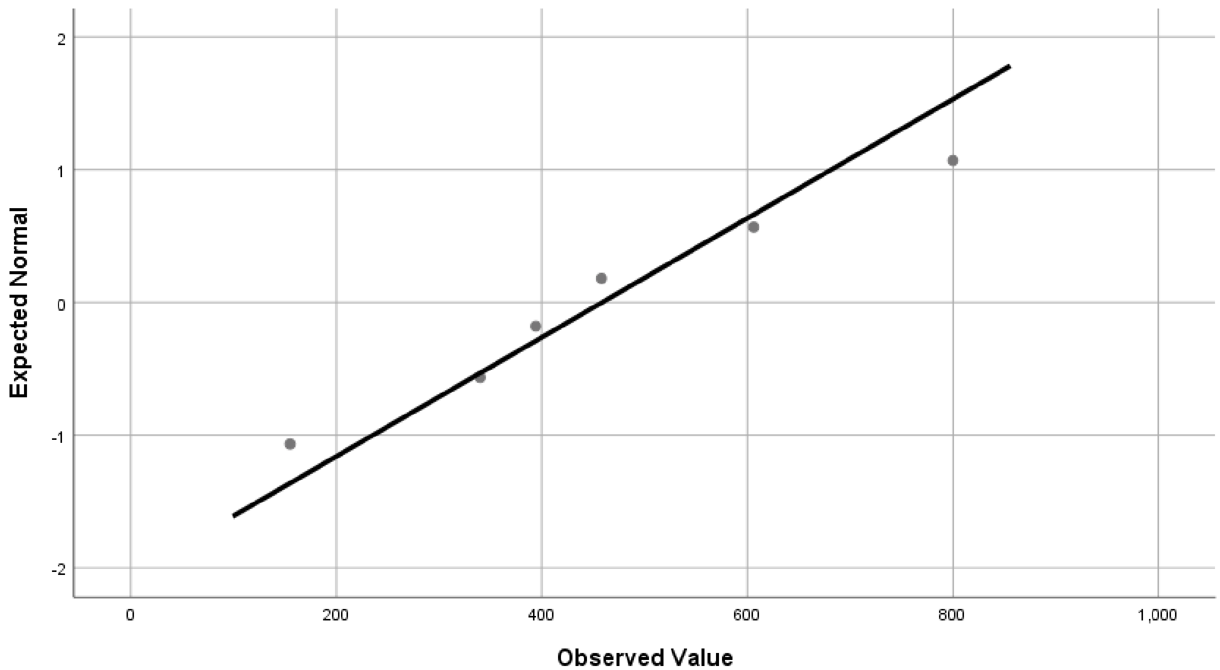


Figure 2.23

Normal P-P Plot of Regression Standardized Residual for Mechanical Engineering

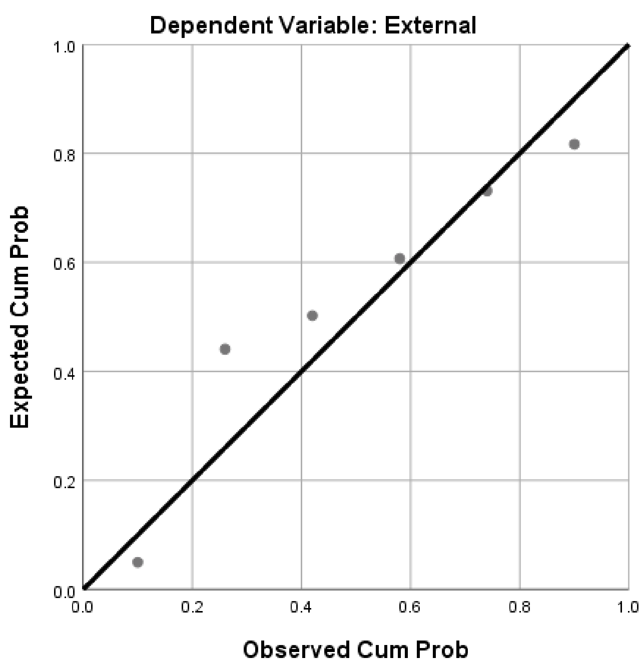
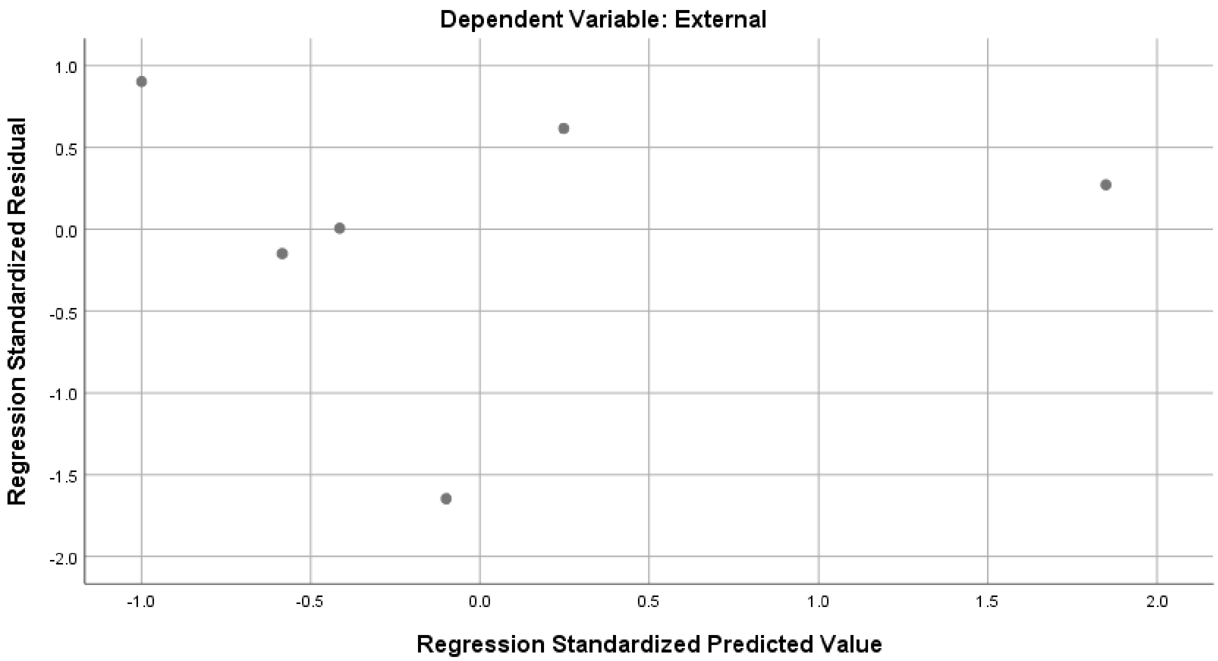


Figure 2.24

Scatterplot for Mechanical Engineering



Other Engineering

The NSF HERD Survey (n.d.) categorizes any Engineering fields that cannot be specifically identified within the previously listed subfields as Other Engineering. Table 2.7 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Engineering R&D expenditures. Figure 2.25 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.26. Standardized residuals were not normally distributed as shown in Figure 2.27. Scatterplots in Figure 2.28 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Engineering subfield, $F(1,4)$ =

1.43, $p = .297$. A large effect size was noted with approximately 26.4% of the variances accounted for in the model, $R^2 = .264$.

Table 2.7

Descriptive Statistics for Other Engineering (n = 6 and r = -0.51)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	1816	722
2016	1625	468
2017	998	713
2018	1452	451
2019	1519	200
2020	7589	236
M	2499.83	465.00
SD	2507.91	223.80

Figure 2.25

Scatter Plot of External by Institutional for Other Engineering

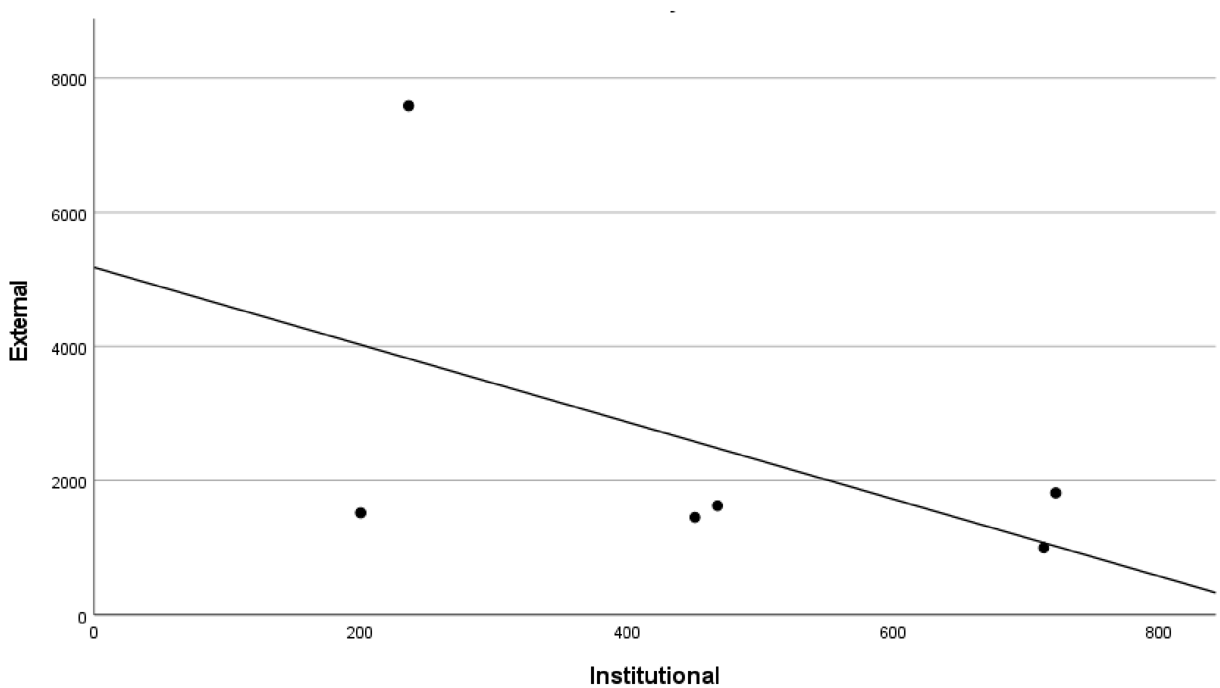


Figure 2.26

Normal Q-Q Plot of External for Other Engineering

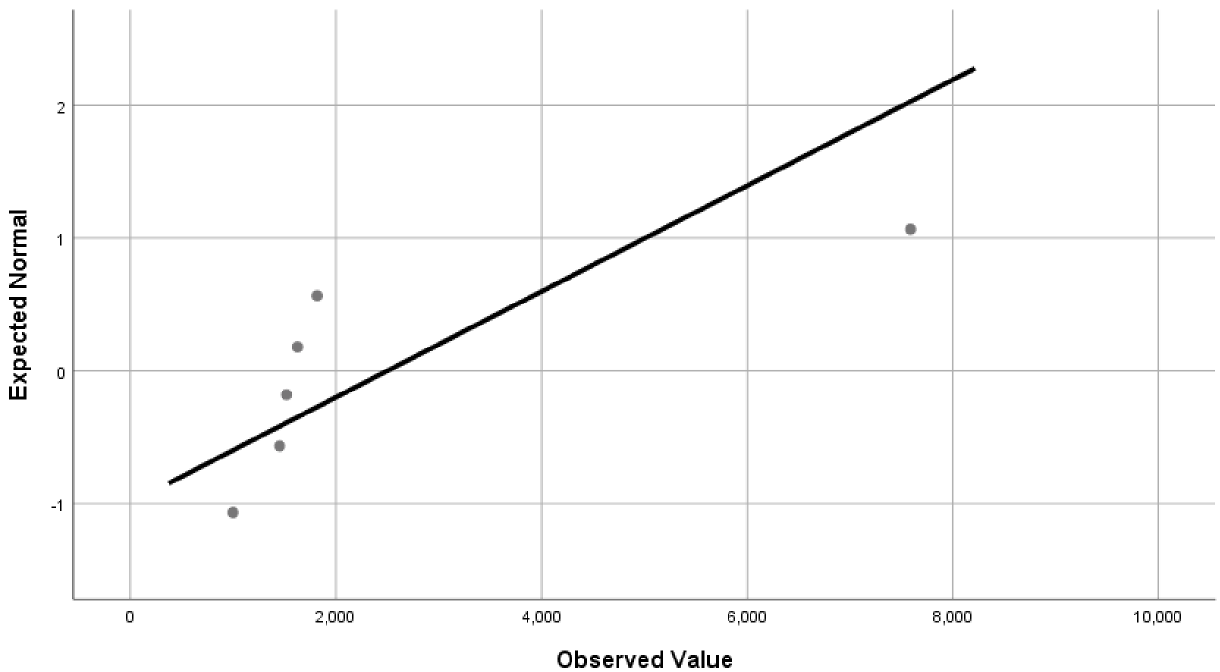


Figure 2.27

Normal P-P Plot of Regression Standardized Residual for Other Engineering

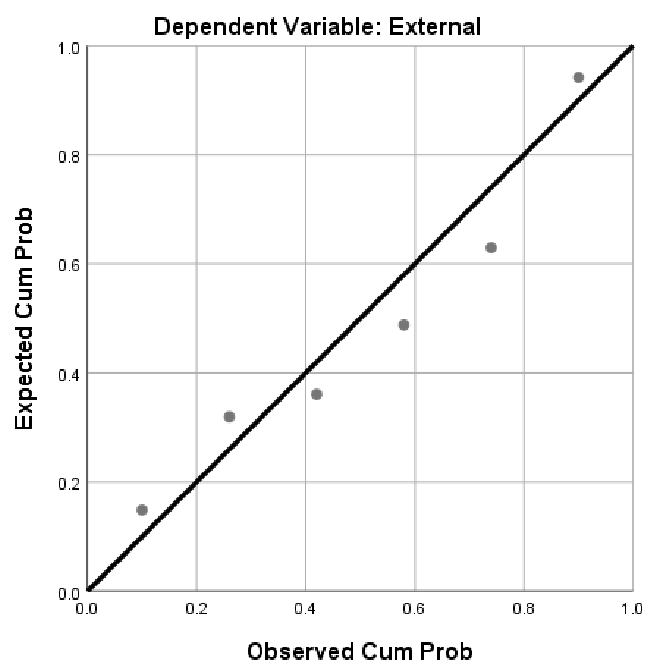
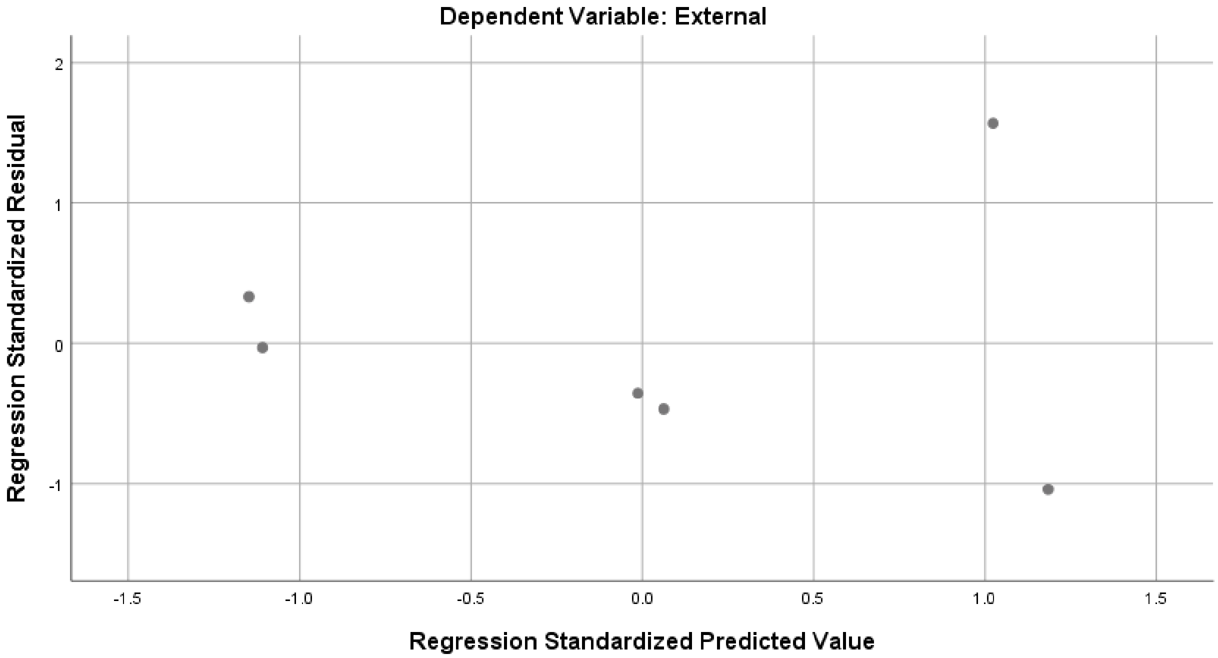


Figure 2.28

Scatterplot for Other Engineering



Geosciences, Atmospheric Sciences, and Ocean Sciences

Table 2.8 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Geosciences, Atmospheric Sciences, and Ocean (GAS&O) Sciences R&D expenditures. Figure 2.29 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Geosciences, Atmospheric Sciences, and Ocean Sciences field reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.30. Standardized residuals were somewhat normally distributed as shown in Figure 2.31 as half of the values fall closely along the line. Scatterplots in Figure 2.32 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Geosciences, Atmospheric Sciences, and Ocean Sciences field, $F(1,4) = 1.44$, $p = .296$. A large effect size was noted with approximately 26.5% of the variances accounted for in the model, $R^2 = .265$.

Table 2.8

Descriptive Statistics for GAS&O Sciences (n = 6 and r = -0.52)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	7729	457
2016	2355	821
2017	1000	678
2018	1132	665
2019	964	762
2020	648	503
M	2304.67	647.67
SD	2721.95	142.56

Figure 2.29

Scatter Plot of External by Institutional for GAS&O Sciences

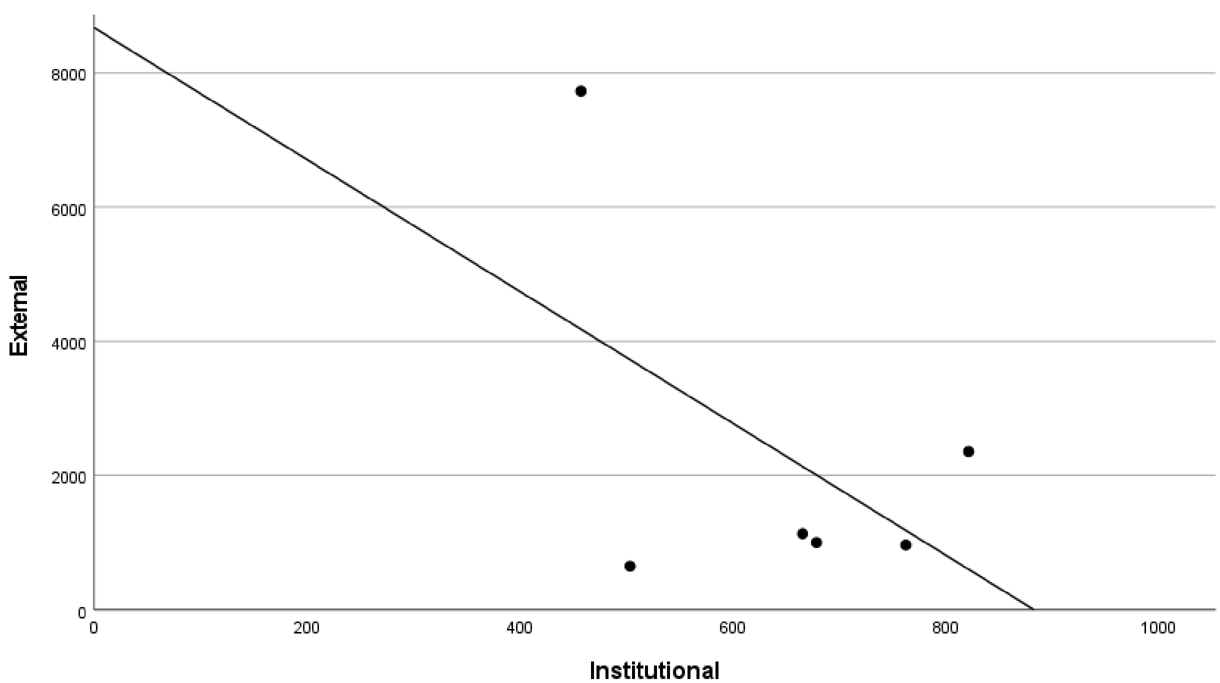


Figure 2.30

Normal Q-Q Plot of External for GAS&O Sciences

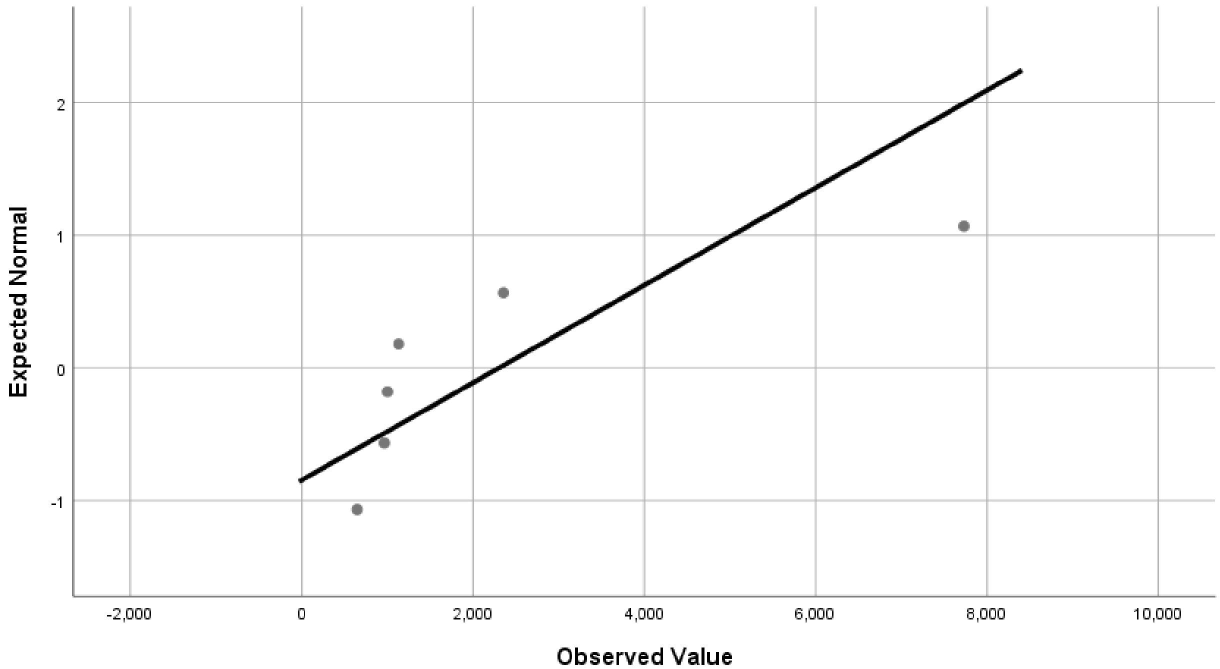


Figure 2.31

Normal P-P Plot of Regression Standardized Residual for GAS&O Sciences

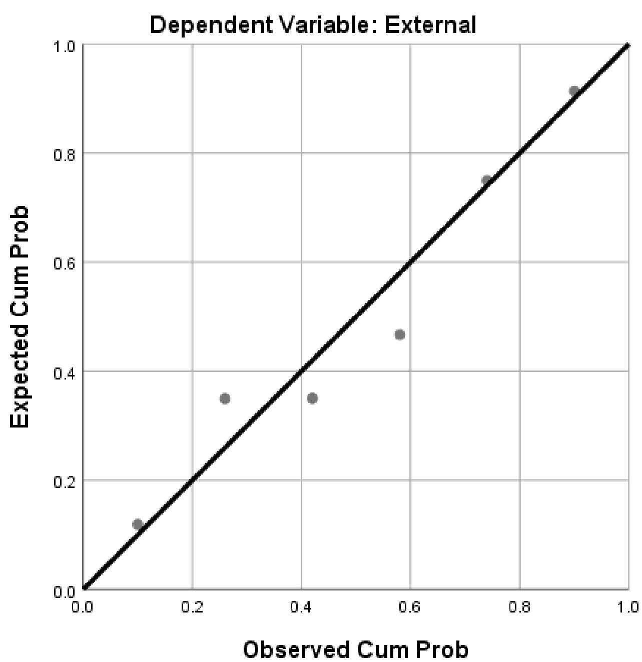
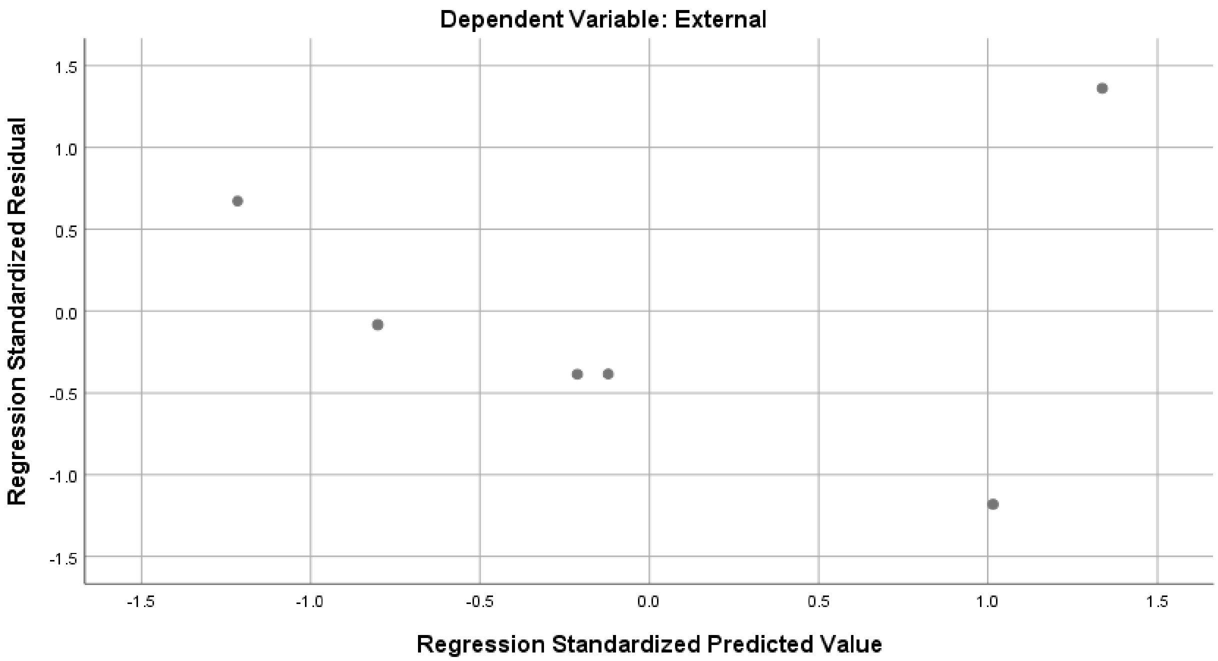


Figure 2.32

Scatterplot for GAS&O Sciences



Geological and Earth Sciences

Table 2.9 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Geological and Earth Sciences R&D expenditures. Figure 2.33 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Geological and Earth Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.34. Standardized residuals were somewhat normally distributed as shown in Figure 2.35 as half of the values fall closely along the line. Scatterplots in Figure 2.36 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Geological and

Earth Sciences subfield, $F(1,4) = 4.09$, $p = .113$. A large effect size was noted with approximately 50.6% of the variances accounted for in the model, $R^2 = .506$.

Table 2.9

Descriptive Statistics for Geological and Earth Sciences (n = 6 and r = 0.71)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	70	84
2016	36	380
2017	208	492
2018	219	529
2019	187	615
2020	79	374
M	133.17	412.33
SD	80.29	185.12

Figure 2.33

Scatter Plot of External by Institutional for Geological and Earth Sciences

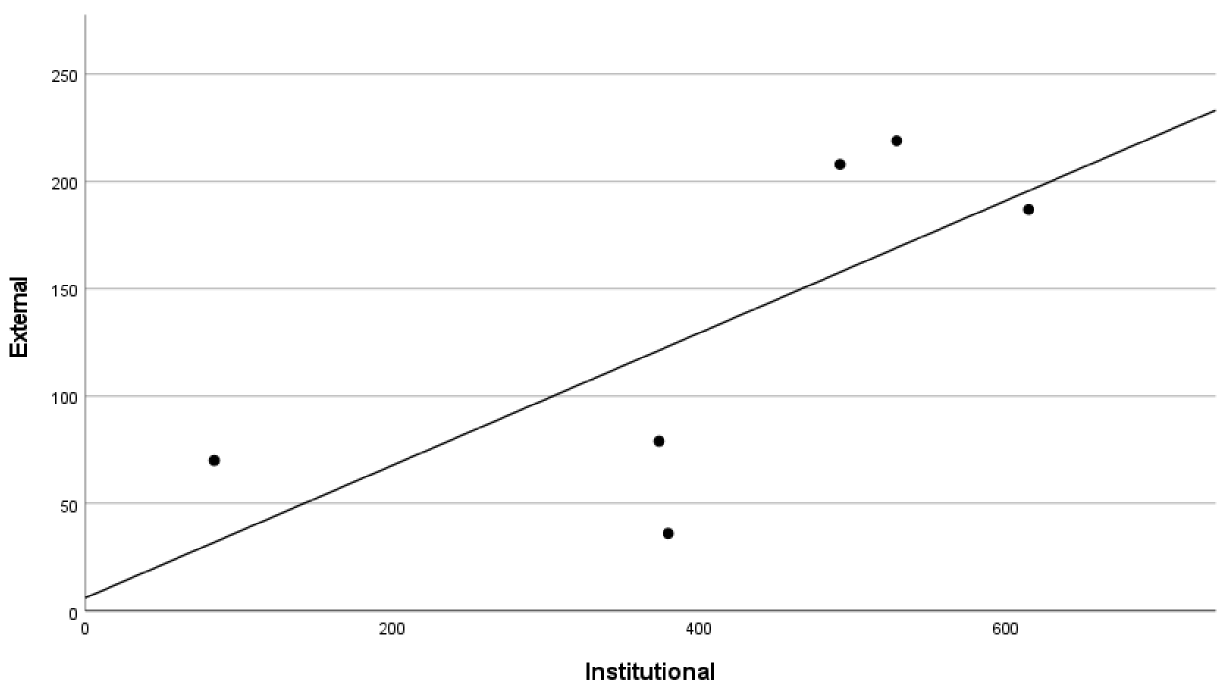


Figure 2.34

Normal Q-Q Plot of External for Geological and Earth Sciences

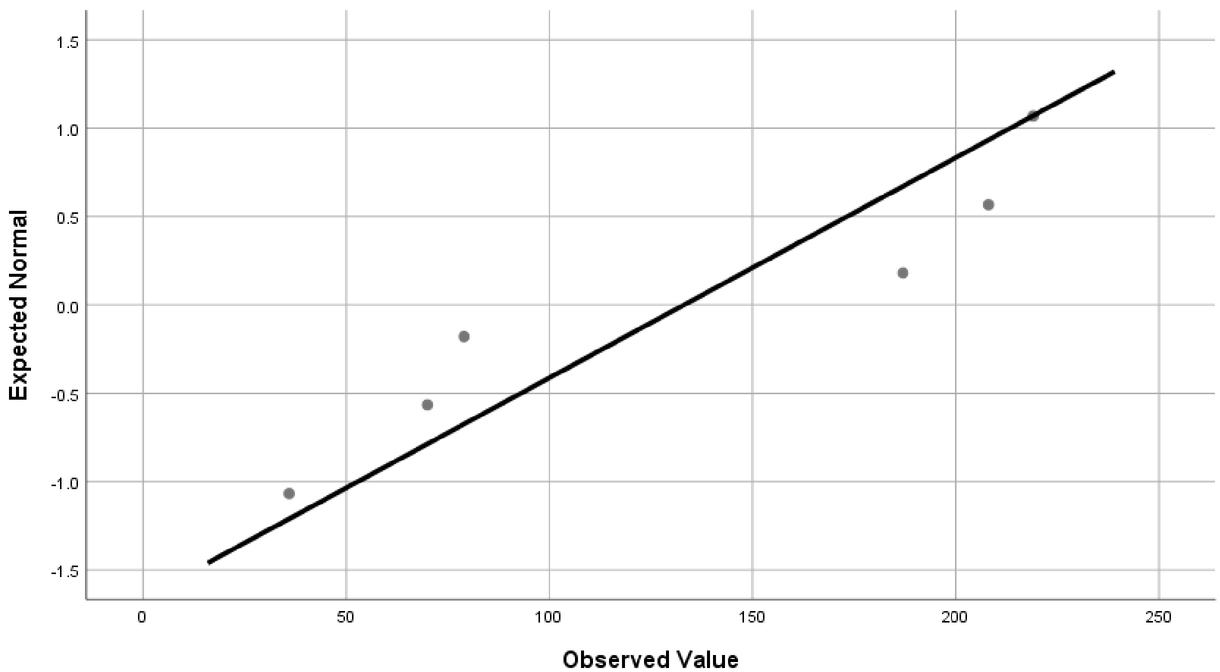


Figure 2.35

Normal P-P Plot of Regression Standardized Residual for Geological and Earth Sciences

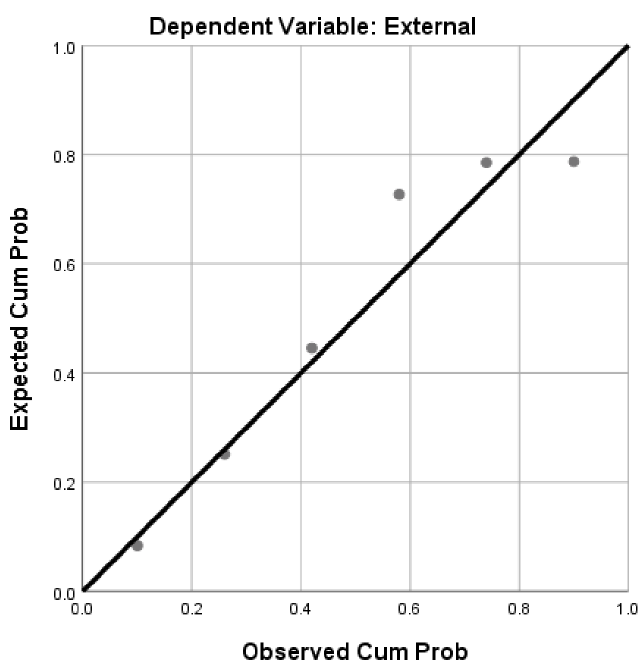
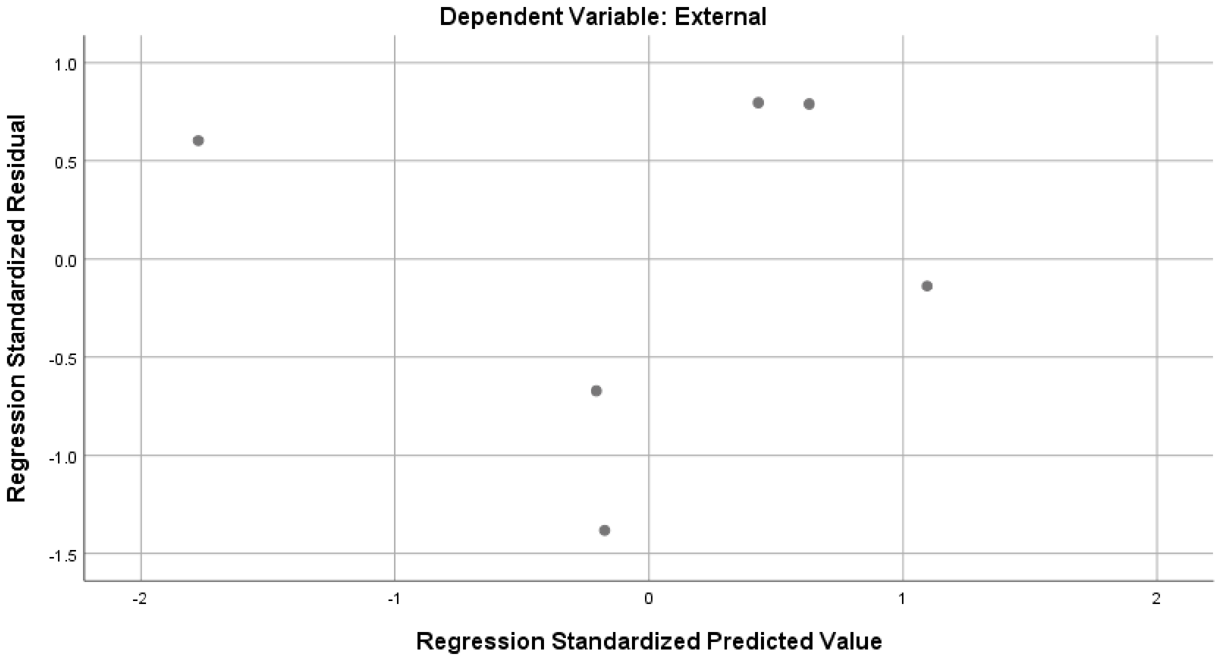


Figure 2.36

Scatterplot for Geological and Earth Sciences



Ocean Sciences and Marine Sciences

Table 2.10 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Ocean Sciences and Marine Sciences R&D expenditures. Figure 2.37 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Ocean Sciences and Marine Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.38. Standardized residuals were not normally distributed as shown in Figure 2.39. Scatterplots in Figure 2.40 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Ocean Sciences and Marine Sciences subfield, $F(1,4) = 3.57$,

$p = .132$. A large effect size was noted with approximately 47.1% of the variances accounted for in the model, $R^2 = .471$.

Table 2.10

Descriptive Statistics for Ocean Sciences and Marine Sciences (n = 6 and r = 0.69)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	7659	373
2016	2319	441
2017	654	185
2018	683	136
2019	777	147
2020	481	129
M	2095.50	235.17
SD	2807.87	136.21

Figure 2.37

Scatter Plot of External by Institutional for Ocean Sciences and Marine Sciences

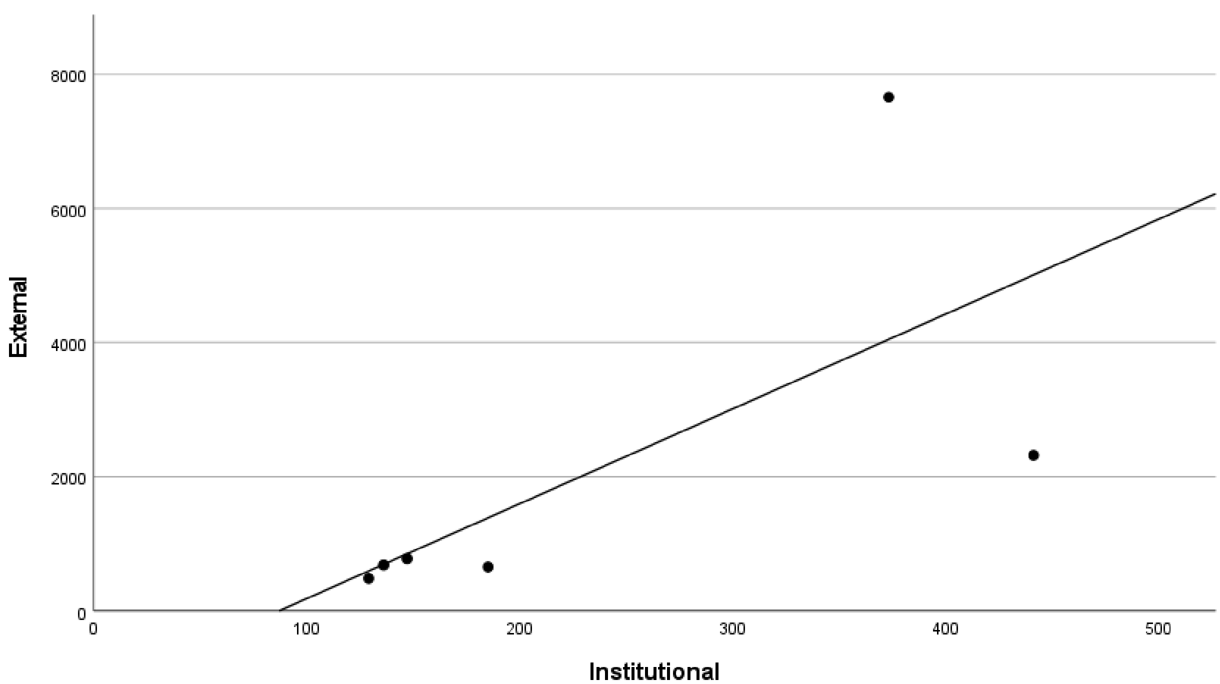


Figure 2.38

Normal Q-Q Plot of External for Ocean Sciences and Marine Sciences

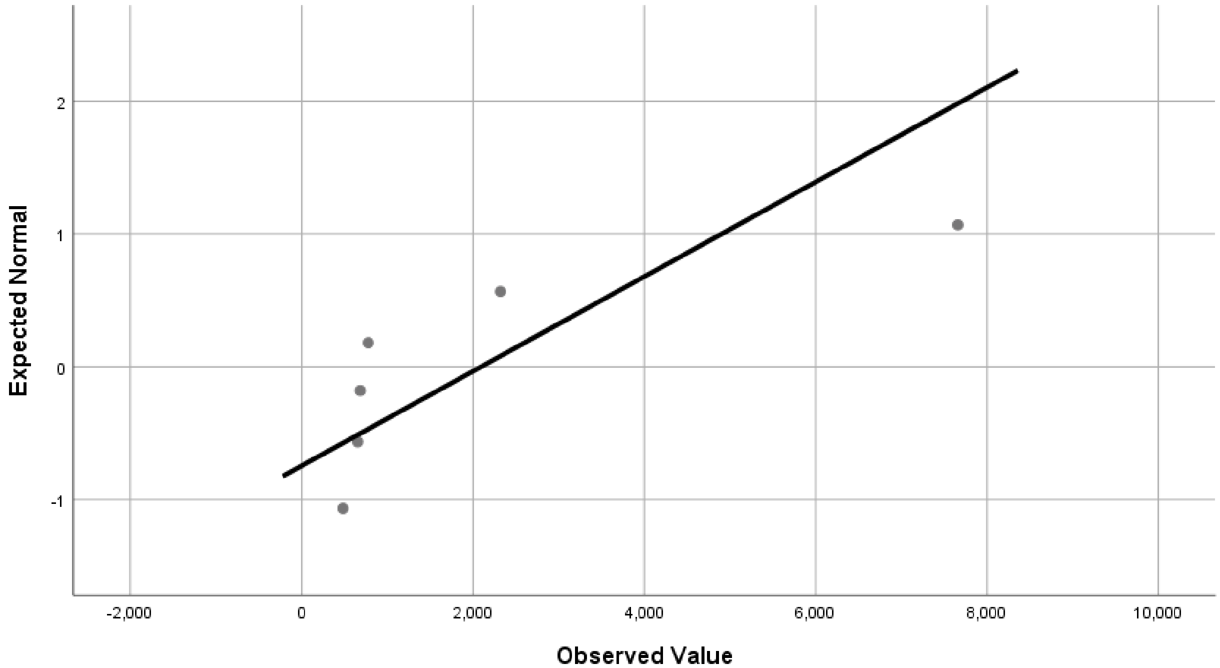


Figure 2.39

Normal P-P Plot of Regression Standardized Residual for Ocean Sciences and Marine Sciences

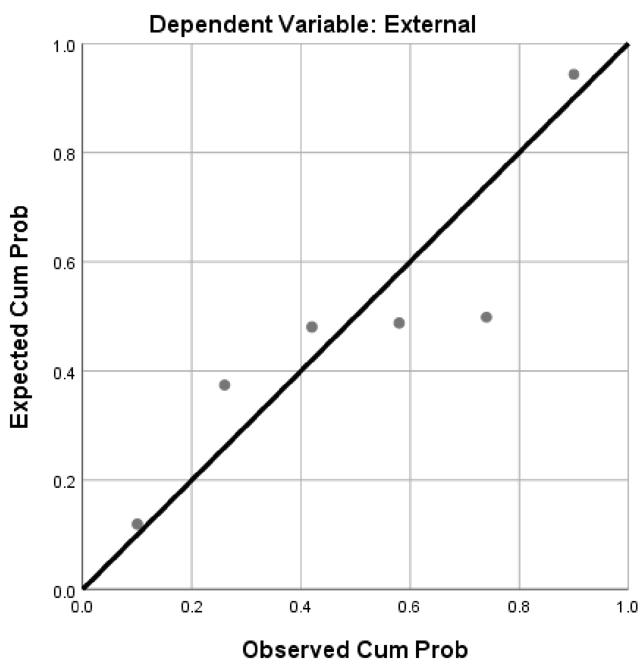
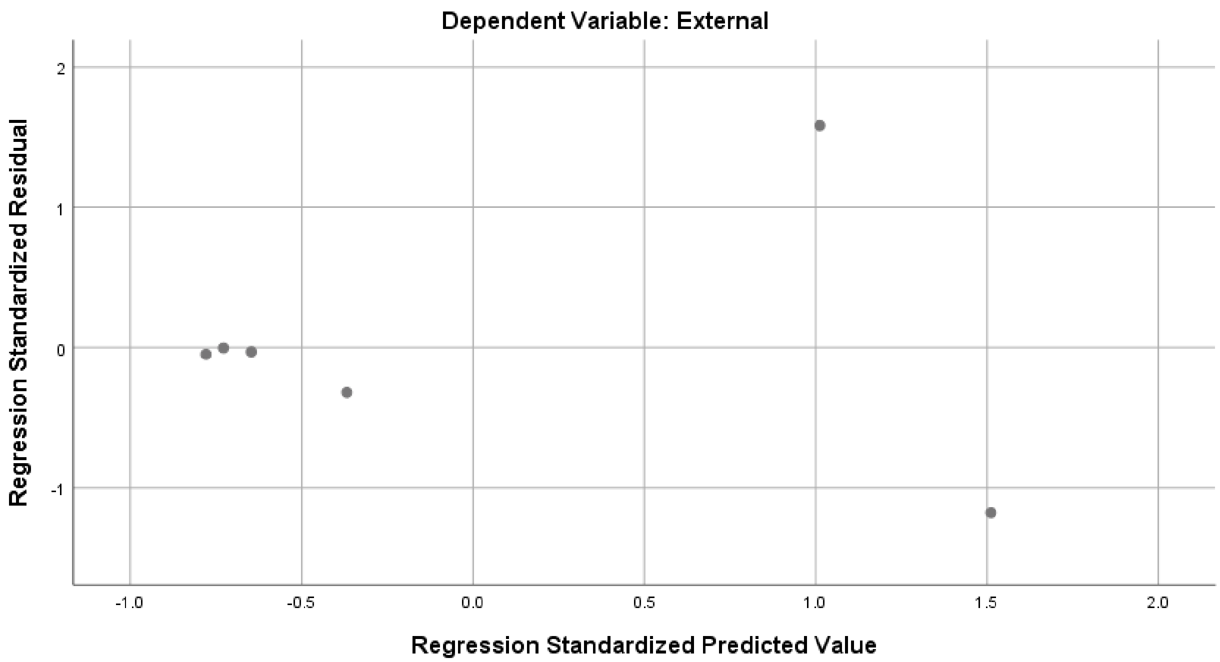


Figure 2.40

Scatterplot for Ocean Sciences and Marine Sciences



Life Sciences

Table 2.11 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Life Sciences R&D expenditures. Figure 2.41 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Life Sciences field reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.42. Standardized residuals were somewhat normally distributed as shown in Figure 2.43 as half of the values fall closely along the line. Scatterplots in Figure 2.44 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Life Sciences field, $F(1,4) = .33$, $p = .598$. A small effect size was noted with approximately 7.5% of the variances accounted for in the model, $R^2 = .075$.

Table 2.11

Descriptive Statistics for Life Sciences (n = 6 and r = 0.28)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	54635	9990
2016	57669	14829
2017	55538	28445
2018	58733	32518
2019	66678	37204
2020	69196	16933
M	60408.17	23319.83
SD	6064.55	10901.51

Figure 2.41

Scatter Plot of External by Institutional for Life Sciences

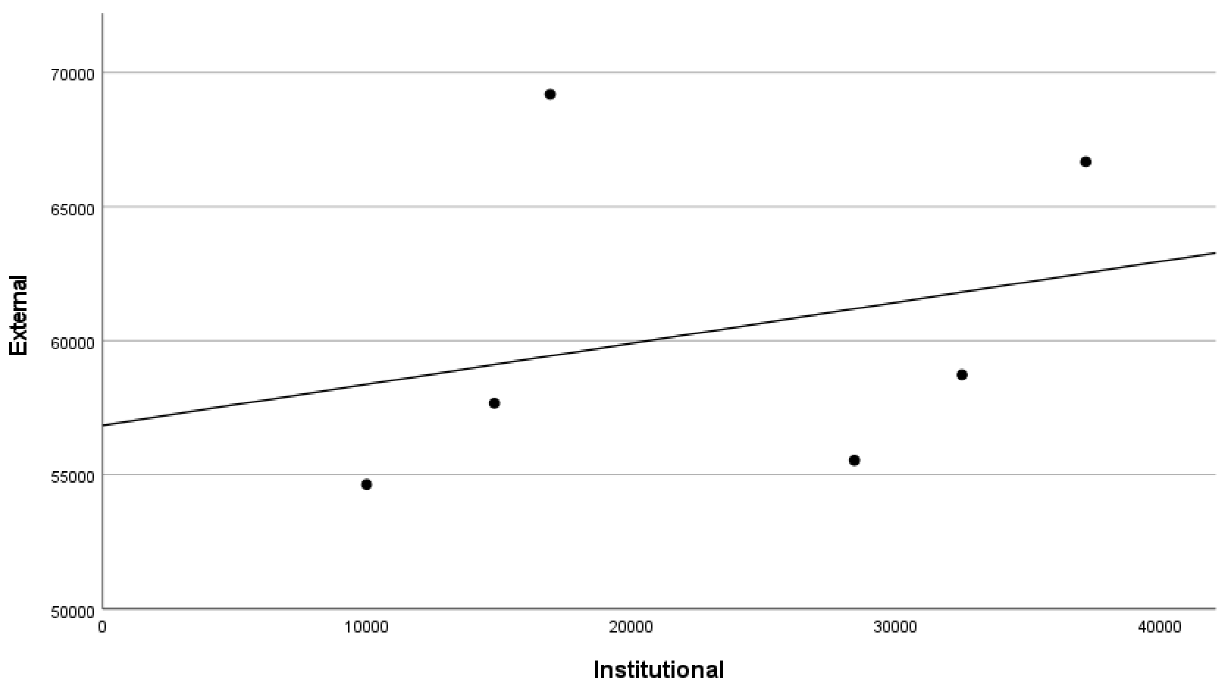


Figure 2.42

Normal Q-Q Plot of External for Life Sciences

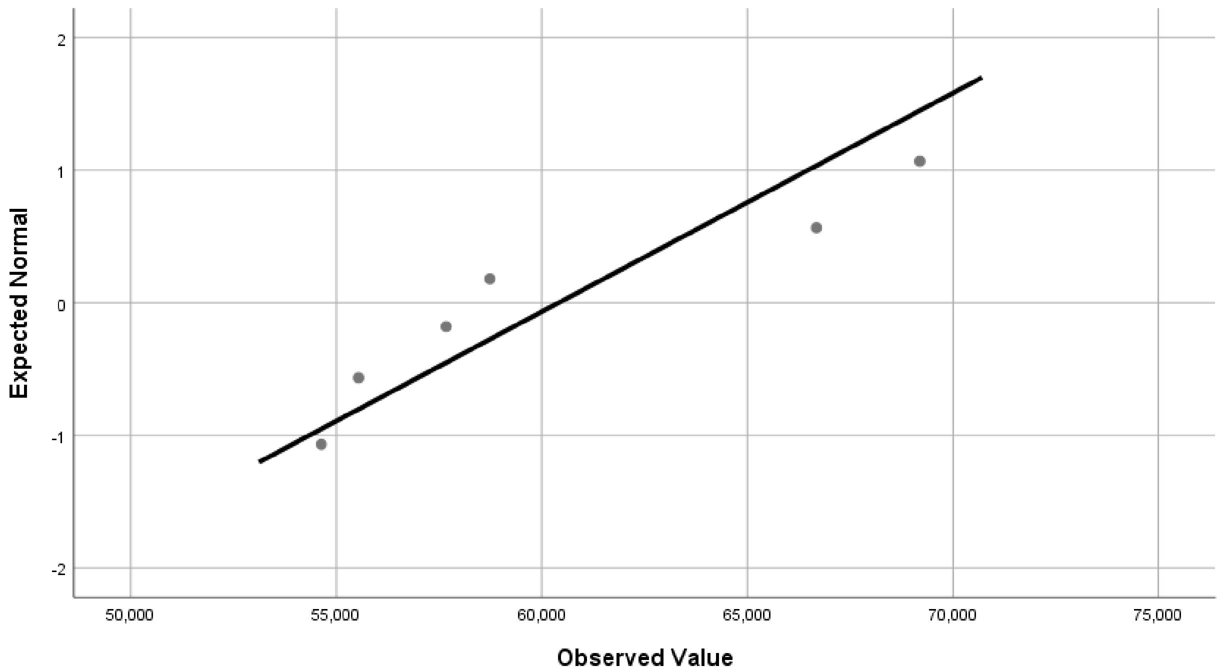


Figure 2.43

Normal P-P Plot of Regression Standardized Residual for Life Sciences

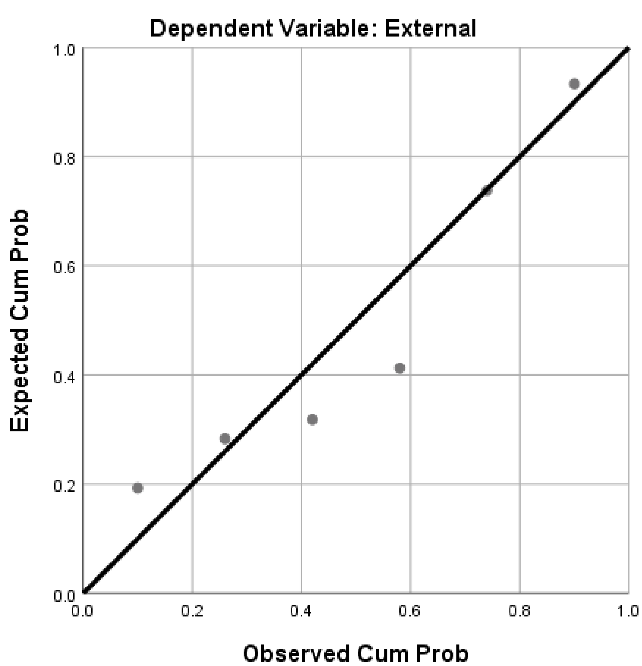
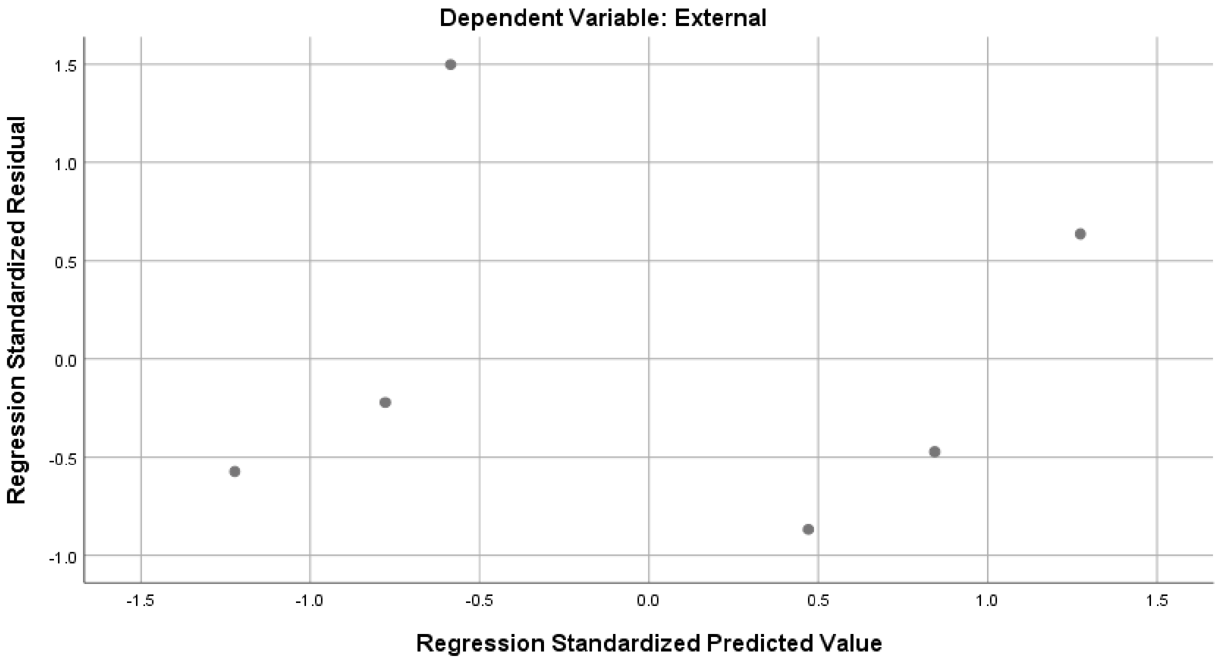


Figure 2.44

Scatterplot for Life Sciences



Biological and Biomedical Sciences

Table 2.12 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Biological and Biomedical Sciences R&D expenditures. Figure 2.45 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Biological and Biomedical Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.46 as half of the values fall closely along the line. Standardized residuals were not normally distributed as shown in Figure 2.47. Scatterplots in Figure 2.48 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Biological and

Biomedical Sciences subfield, $F(1,4) = 3.88$, $p = .120$. A large effect size was noted with approximately 49.2% of the variances accounted for in the model, $R^2 = .492$.

Table 2.12

Descriptive Statistics for Biological and Biomedical Sciences (n = 6 and r = 0.70)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	16058	3133
2016	16062	3747
2017	16978	5280
2018	21994	7299
2019	27714	5680
2020	12348	3518
M	18525.67	4776.17
SD	5462.10	1598.60

Figure 2.45

Scatter Plot of External by Institutional for Biological and Biomedical Sciences

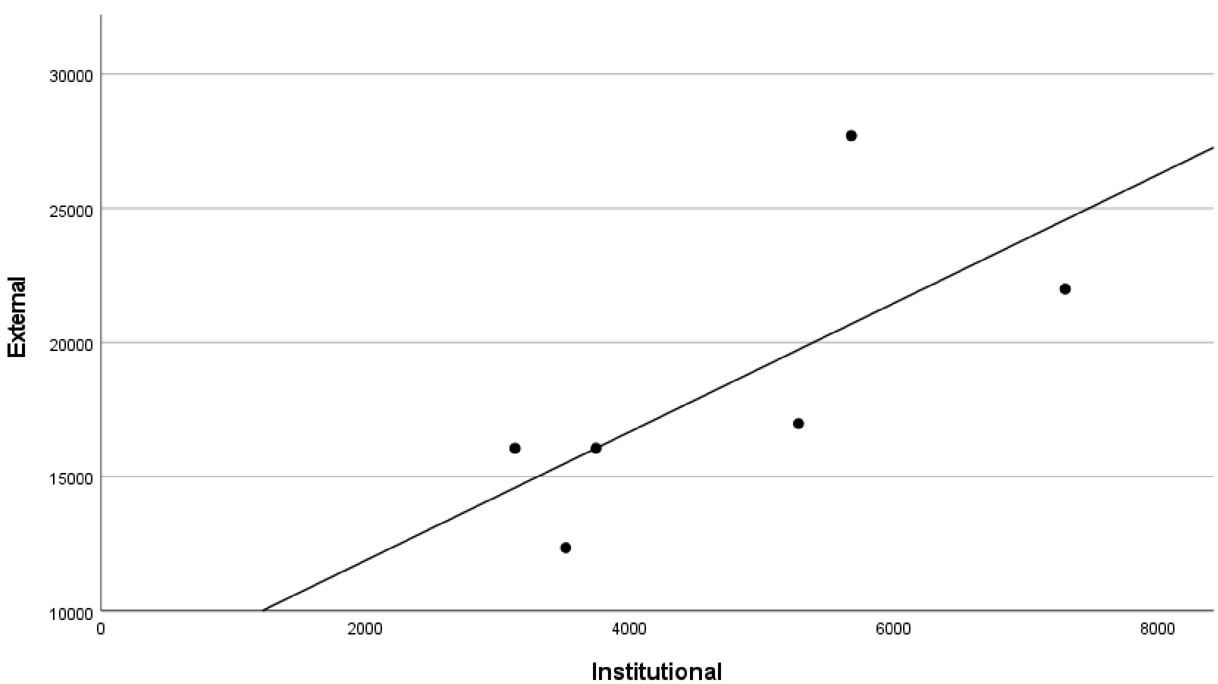


Figure 2.46

Normal Q-Q Plot of External for Biological and Biomedical Sciences

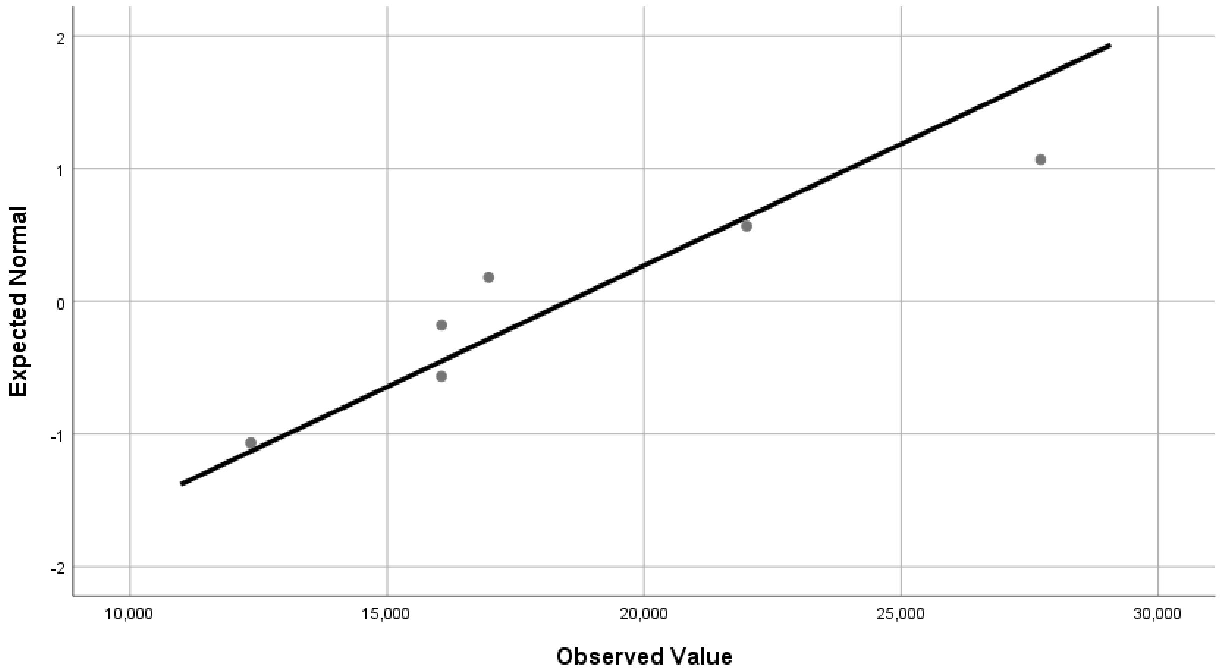


Figure 2.47

Normal P-P Plot of Regression Standardized Residual for Biological and Biomedical Sciences

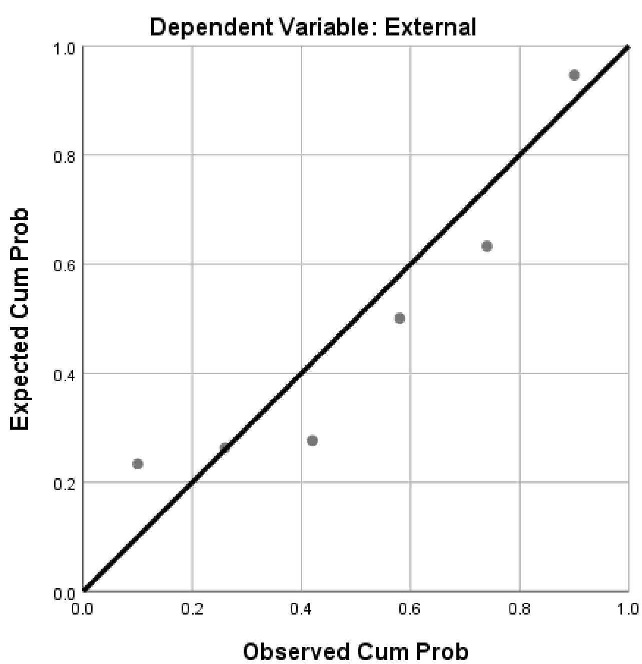
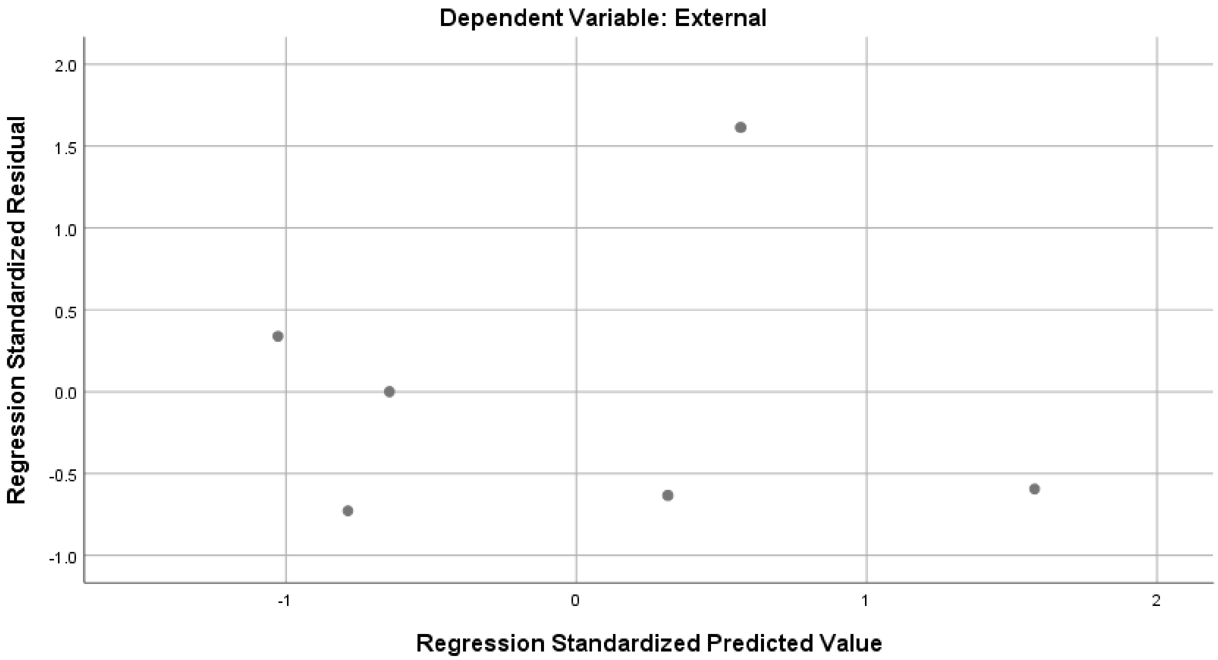


Figure 2.48

Scatterplot for Biological and Biomedical Sciences



Health Sciences

Table 2.13 details expenditures, mean (*M)*, and standard deviation (*SD*) for externally and institutionally funded Health Sciences R&D expenditures. Figure 2.49 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Health Sciences subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.50. Standardized residuals were not normally distributed as shown in Figure 2.51. Scatterplots in Figure 2.52 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Health Sciences subfield, $F(1,4) = .52$, $p = .512$. A small effect size was noted with approximately 11.4% of the variances accounted for in the model, $R^2 = .114$.

Table 2.13

Descriptive Statistics for Health Sciences (n = 6 and r = -0.34)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	36252	6410
2016	39024	10714
2017	35655	20794
2018	34369	21213
2019	36850	23359
2020	54866	12180
M	39502.67	15778.33
SD	7681.45	6906.81

Figure 2.49

Scatter Plot of External by Institutional for Health Sciences

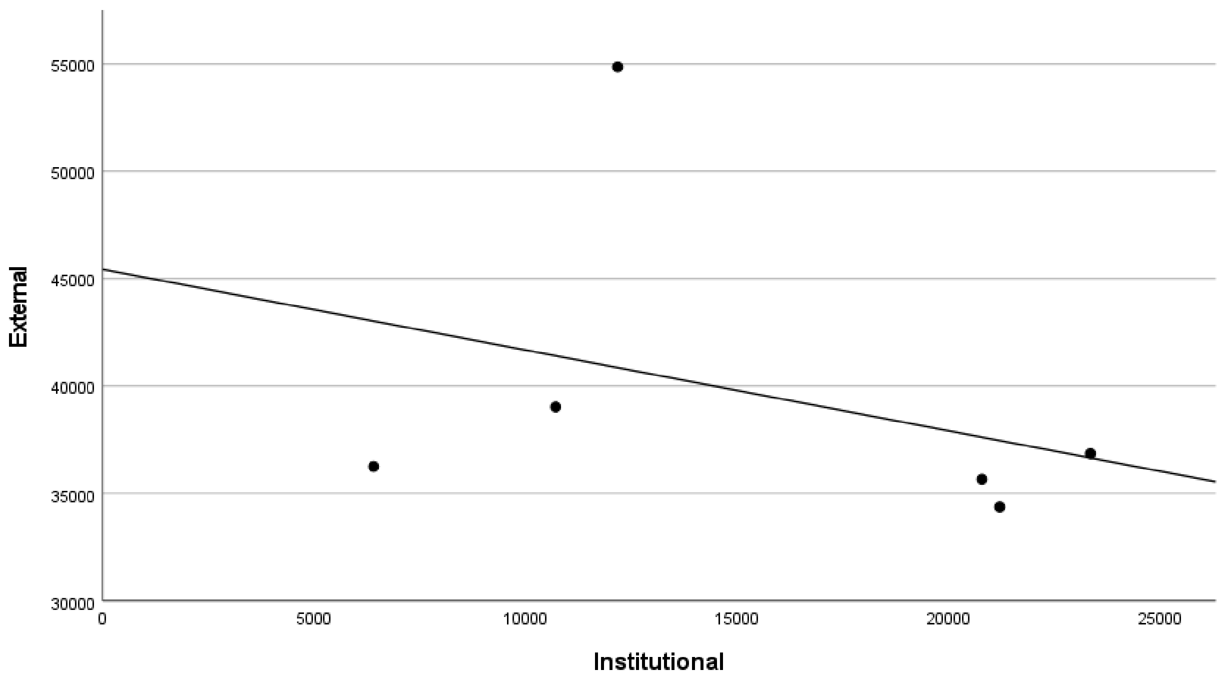


Figure 2.50

Normal Q-Q Plot of External for Health Sciences

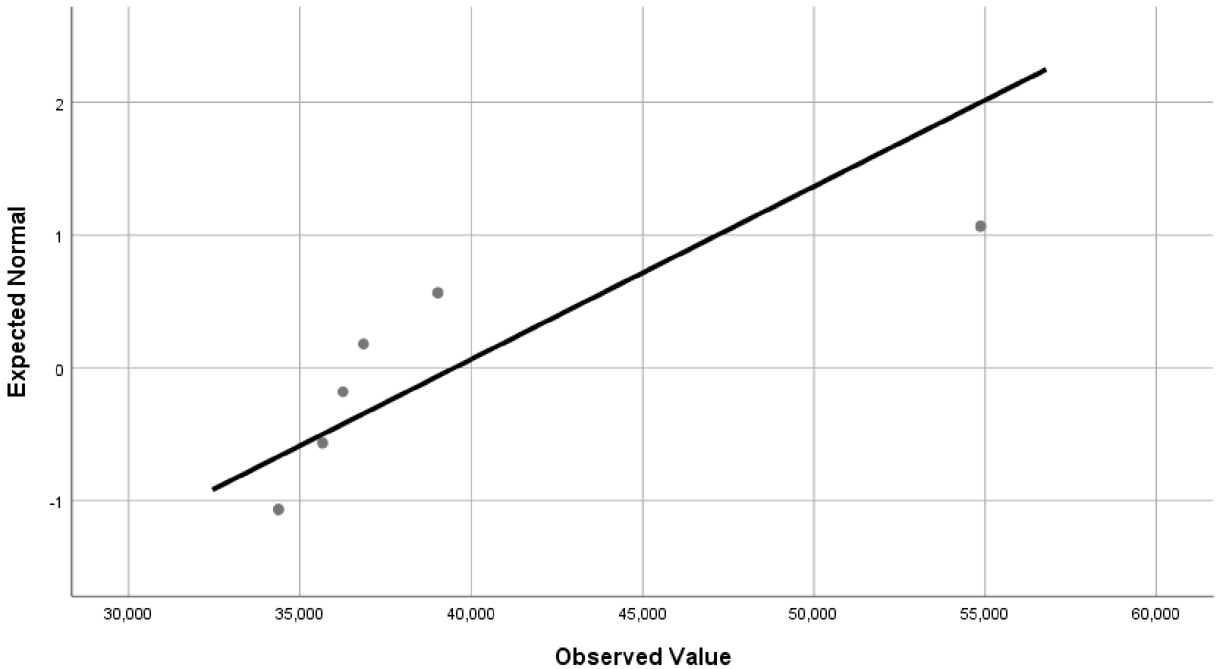


Figure 2.51

Normal P-P Plot of Regression Standardized Residual for Health Sciences

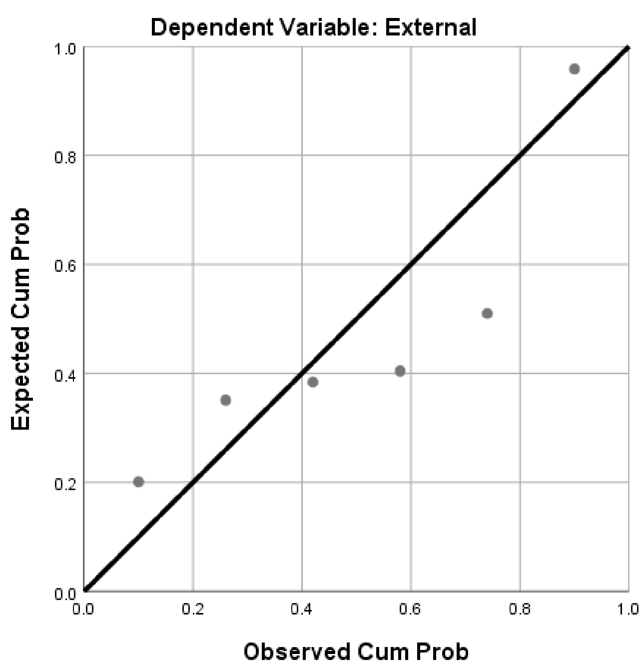
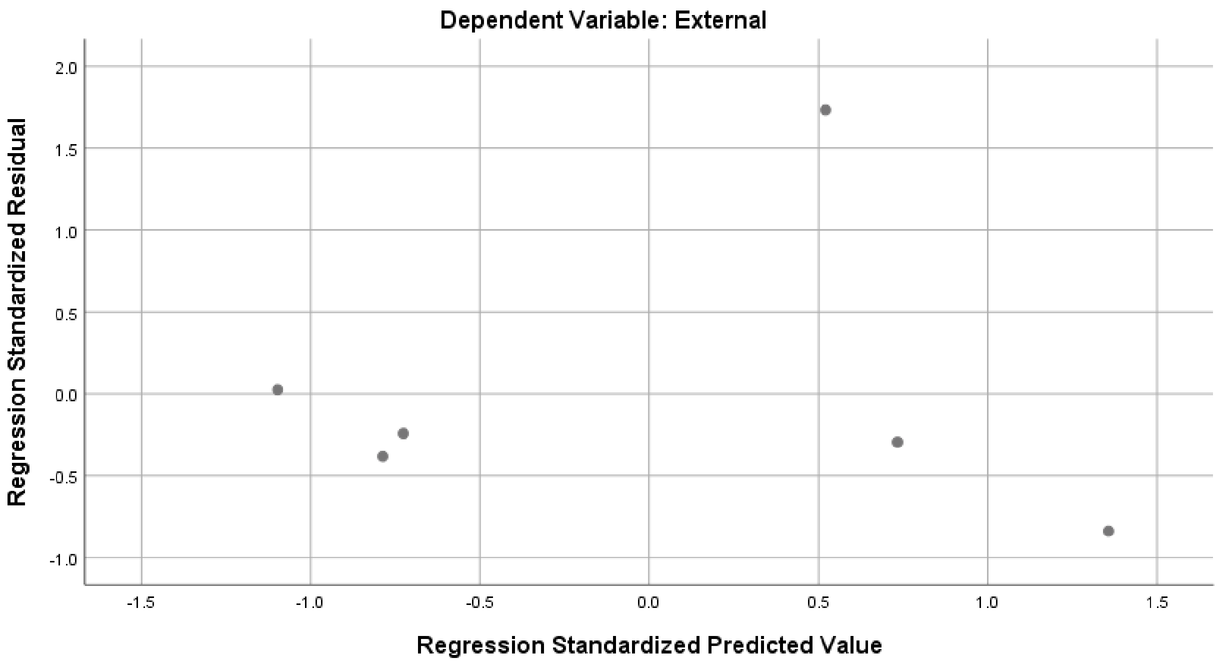


Figure 2.52

Scatterplot for Health Sciences



Other Life Sciences

The NSF HERD Survey (n.d.) categorizes any Life Sciences fields that cannot be specifically identified within the previously listed subfields as Other Life Sciences. Table 2.14 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Life Sciences R&D expenditures. Figure 2.53 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Life Sciences subfield reflecting a negative correlation. Externally funded R&D expenditures were fairly normally distributed as shown in Figure 2.54, and standardized residuals were normally distributed as shown in Figure 2.55 as almost all values fall closely along the line. Scatterplots in Figure 2.56 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Life Sciences subfield, $F(1,4) = .25$, $p = .644$. A small effect size was noted with approximately 5.9% of the variances accounted for in the model, $R^2 = 0.059$.

Table 2.14

Descriptive Statistics for Other Life Sciences (n = 6 and r = -0.24)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	2325	447
2016	2583	368
2017	2890	2366
2018	2361	4003
2019	2114	8165
2020	1886	1235
M	2359.83	2764.00
SD	351.30	2976.96

Figure 2.53

Scatter Plot of External by Institutional for Other Life Sciences

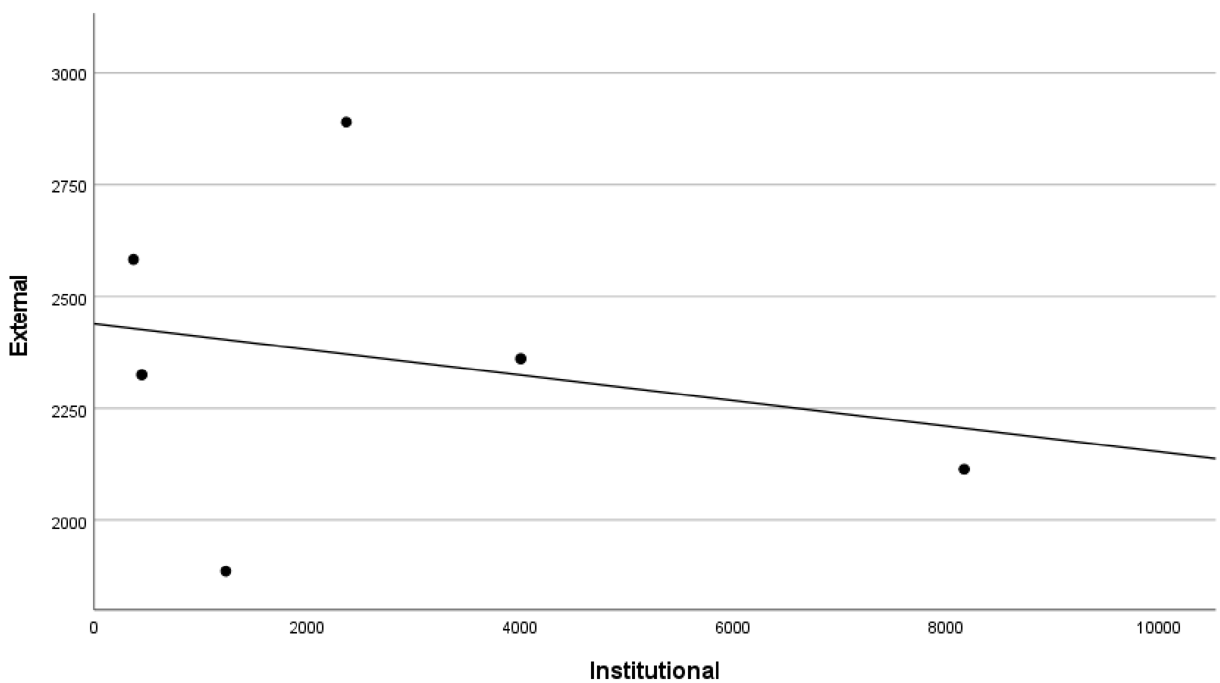


Figure 2.54

Normal Q-Q Plot of External for Other Life Sciences

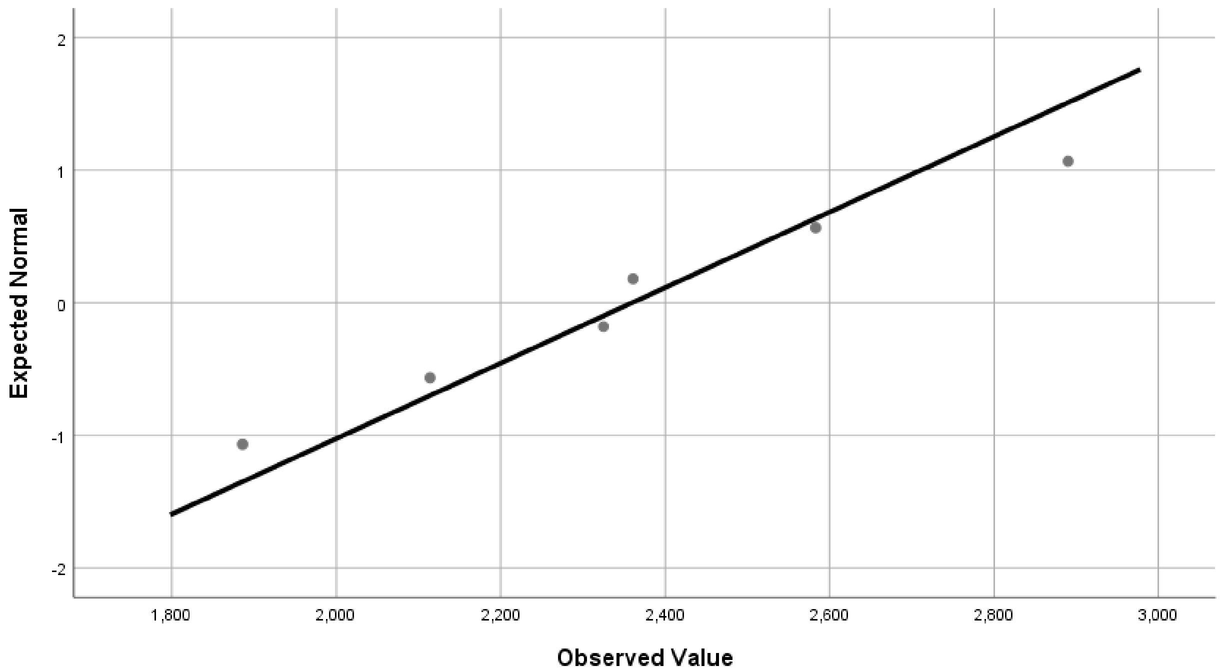


Figure 2.55

Normal P-P Plot of Regression Standardized Residual for Other Life Sciences

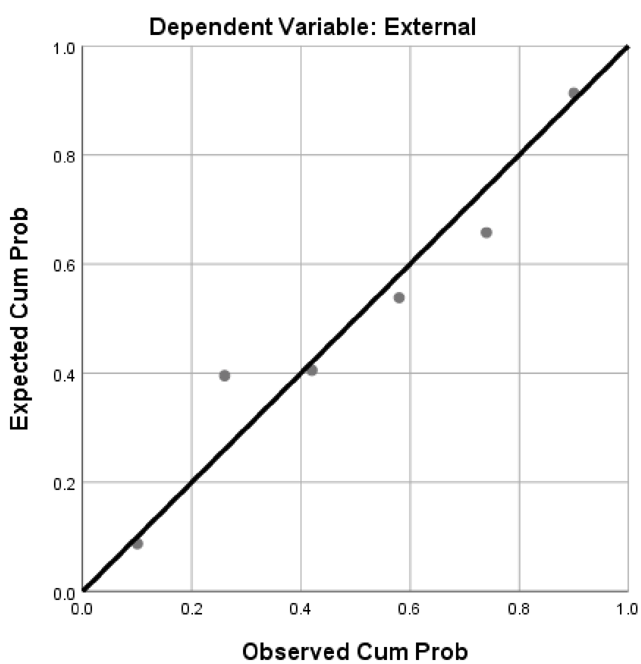
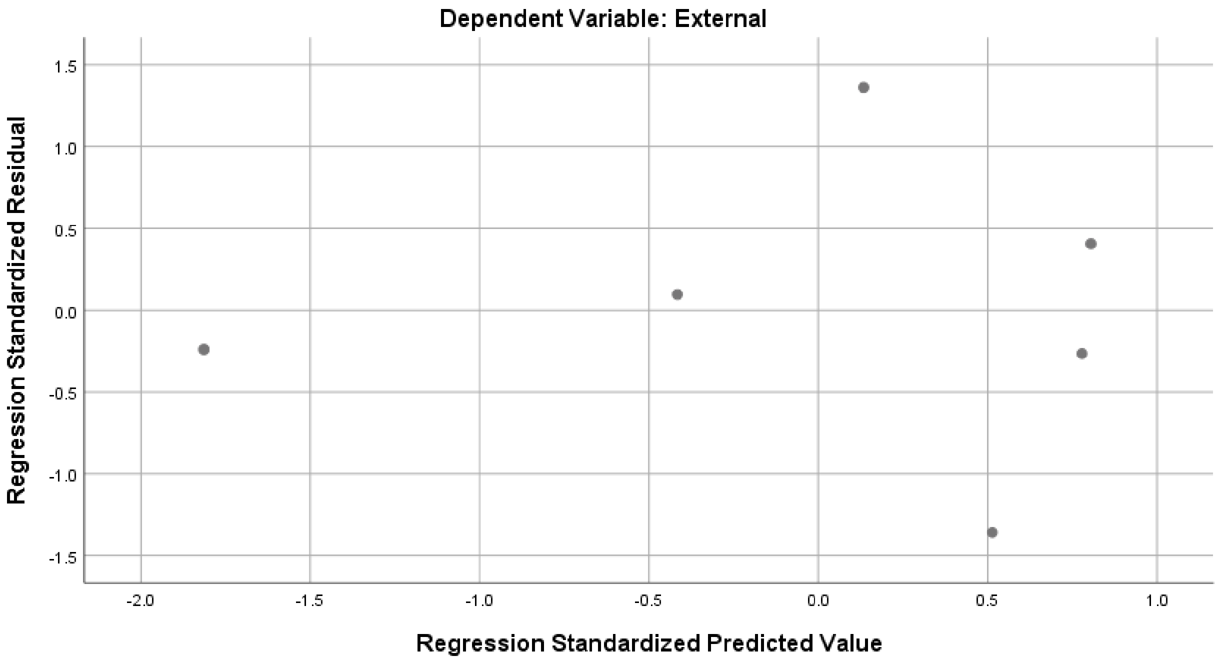


Figure 2.56

Scatterplot for Other Life Sciences



Mathematics and Statistics

Table 2.15 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Mathematics and Statistics R&D expenditures. Figure 2.57 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Mathematics and Statistics field reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.58. Standardized residuals were not normally distributed as shown in Figure 2.59. Scatterplots in Figure 2.60 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Mathematics and Statistics field, $F(1,4) = .01$, $p = .934$. A small effect size was noted with approximately 0.2% of the variances accounted for in the model, $R^2 = .002$.

Table 2.15

Descriptive Statistics for Mathematics and Statistics (n = 6 and r = -0.04)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	84	170
2016	22	1041
2017	24	886
2018	143	880
2019	86	1150
2020	56	160
M	69.17	714.50
SD	45.59	437.50

Figure 2.57

Scatter Plot of External by Institutional for Mathematics and Statistics

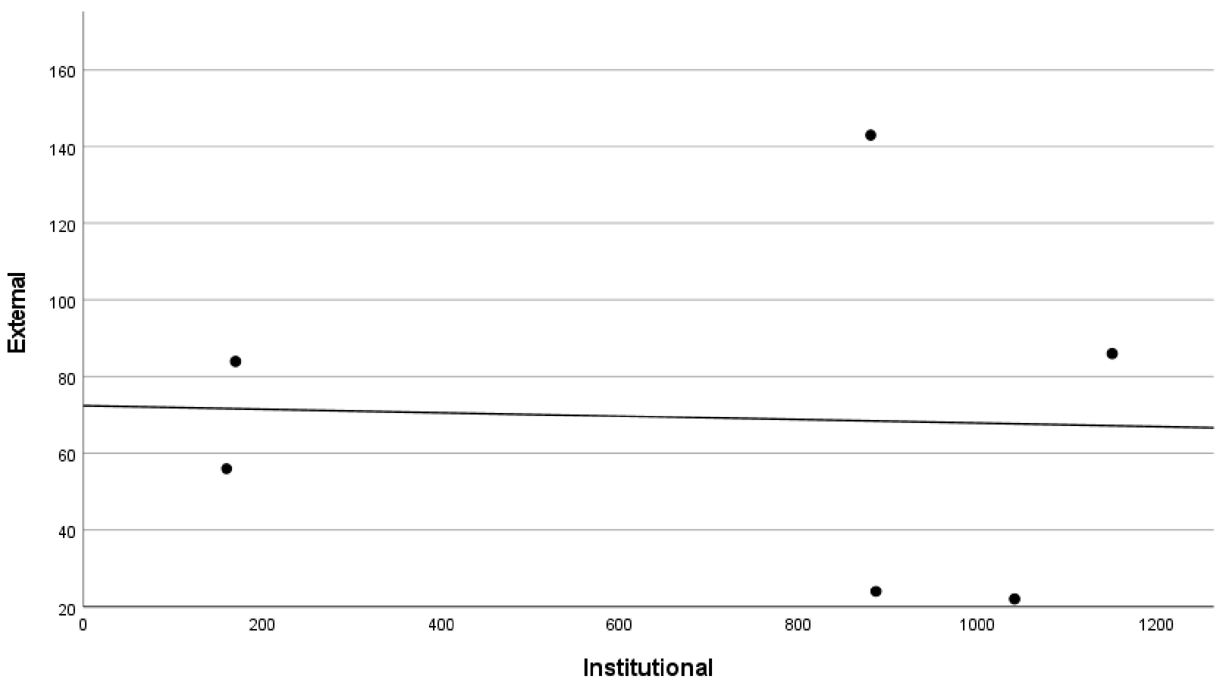


Figure 2.58

Normal Q-Q Plot of External for Mathematics and Statistics

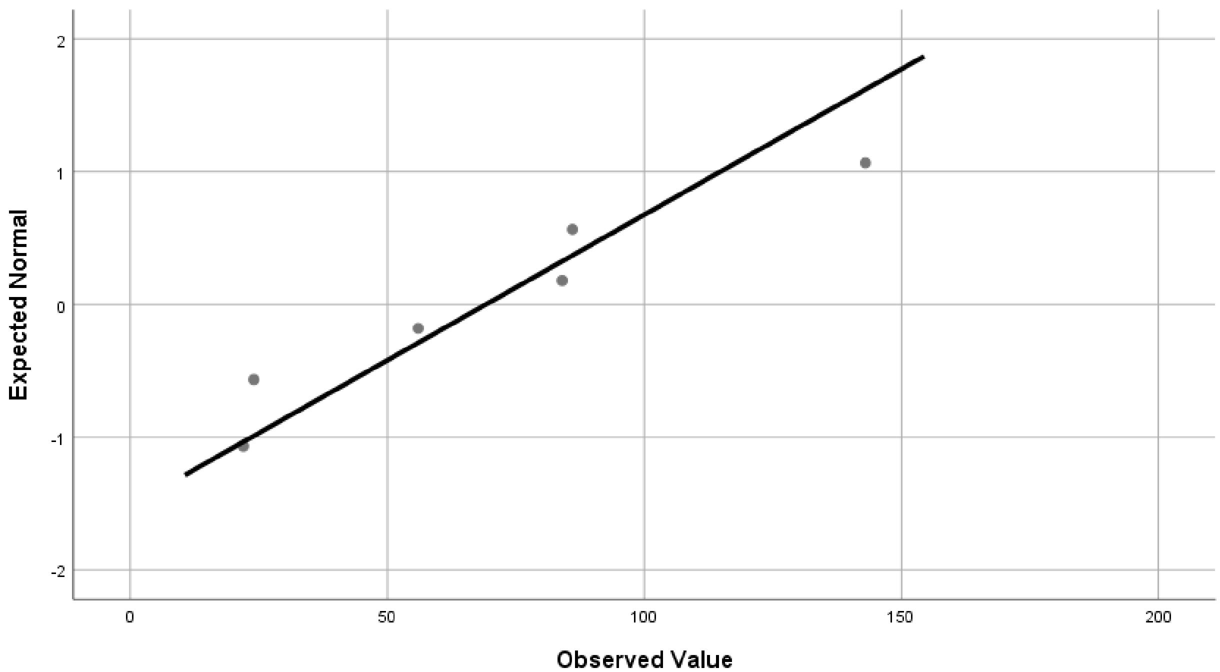


Figure 2.59

Normal P-P Plot of Regression Standardized Residual for Mathematics and Statistics

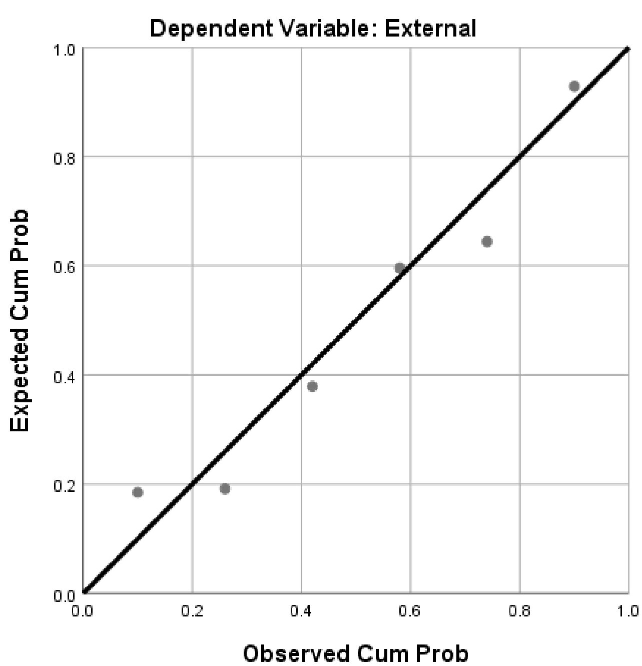
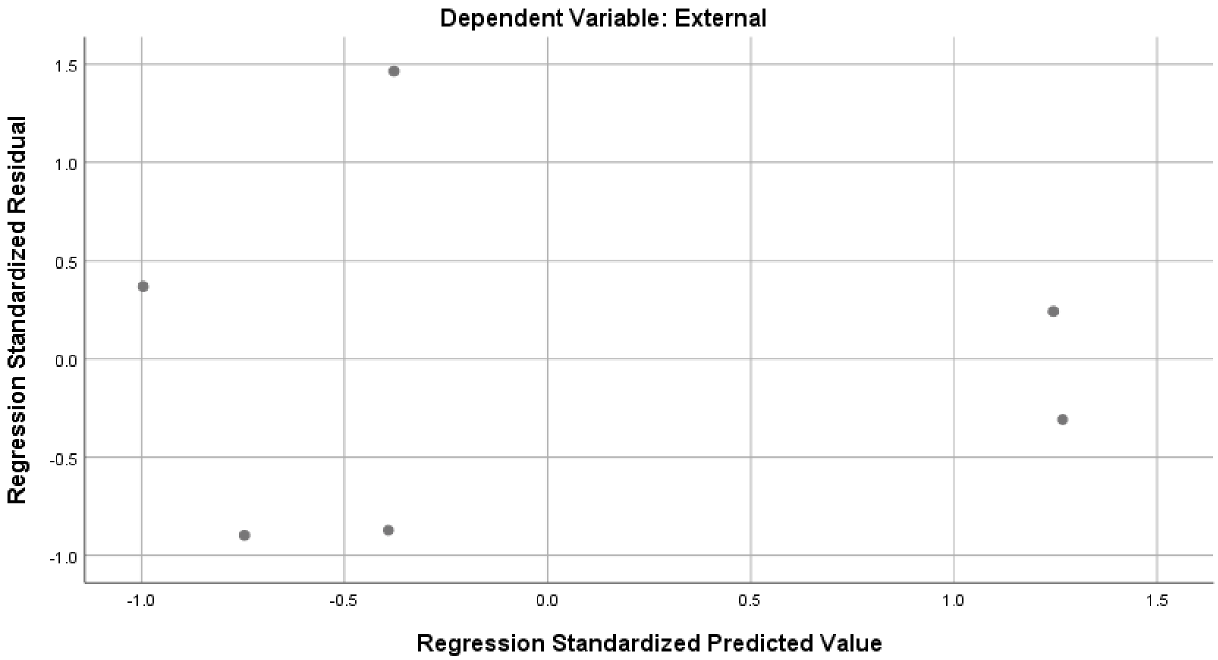


Figure 2.60

Scatterplot for Mathematics and Statistics



Non-Science and Engineering Fields

Table 2.16 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Non-Science and Engineering Fields R&D expenditures. Figure 2.61 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Non-Science and Engineering Fields reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.62. Standardized residuals were not normally distributed as shown in Figure 2.63. Scatterplots in Figure 2.64 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Non-Science and Engineering Fields, $F(1,4) = .03$, $p = .871$. A small effect size was noted with approximately 0.7% of the variances accounted for in the model, $R^2 = .007$.

Table 2.16

Descriptive Statistics for Non-Science and Engineering Fields (n = 6 and r = 0.09)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	1559	2774
2016	1415	17590
2017	2400	17468
2018	2380	17751
2019	2316	19018
2020	2645	4343
M	2119.17	13157.33
SD	504.34	7472.43

Figure 2.61

Scatter Plot of External by Institutional for Non-Science and Engineering Fields

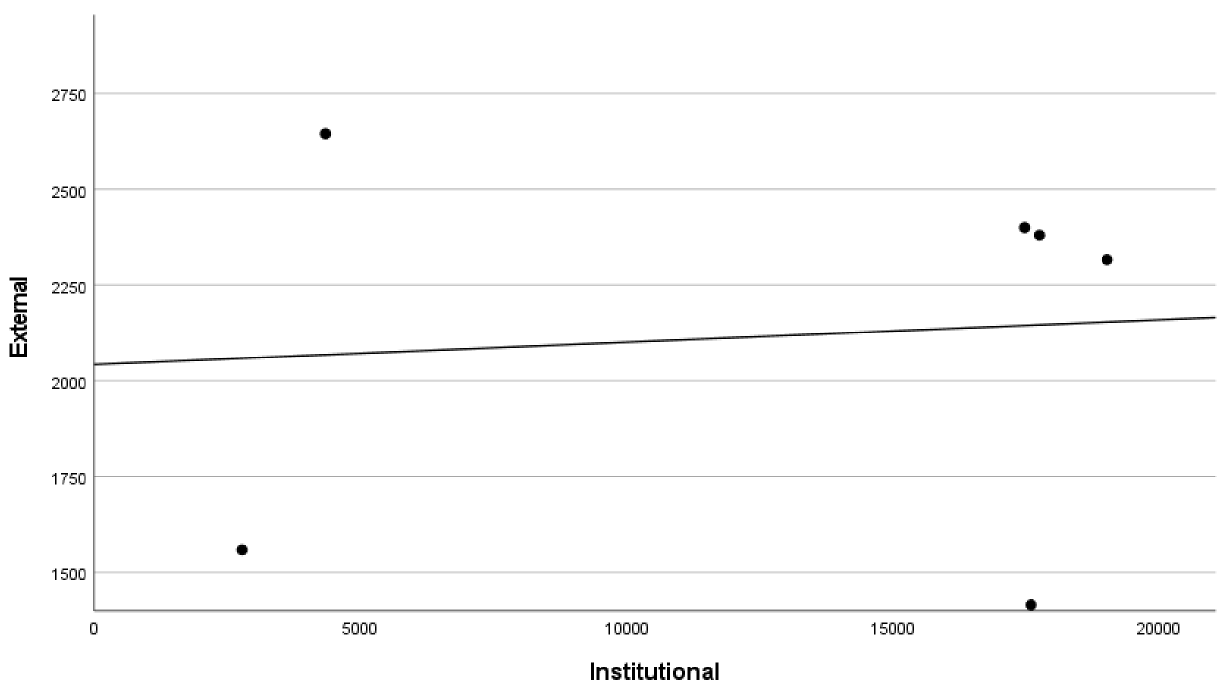


Figure 2.62

Normal Q-Q Plot of External for Non-Science and Engineering Fields

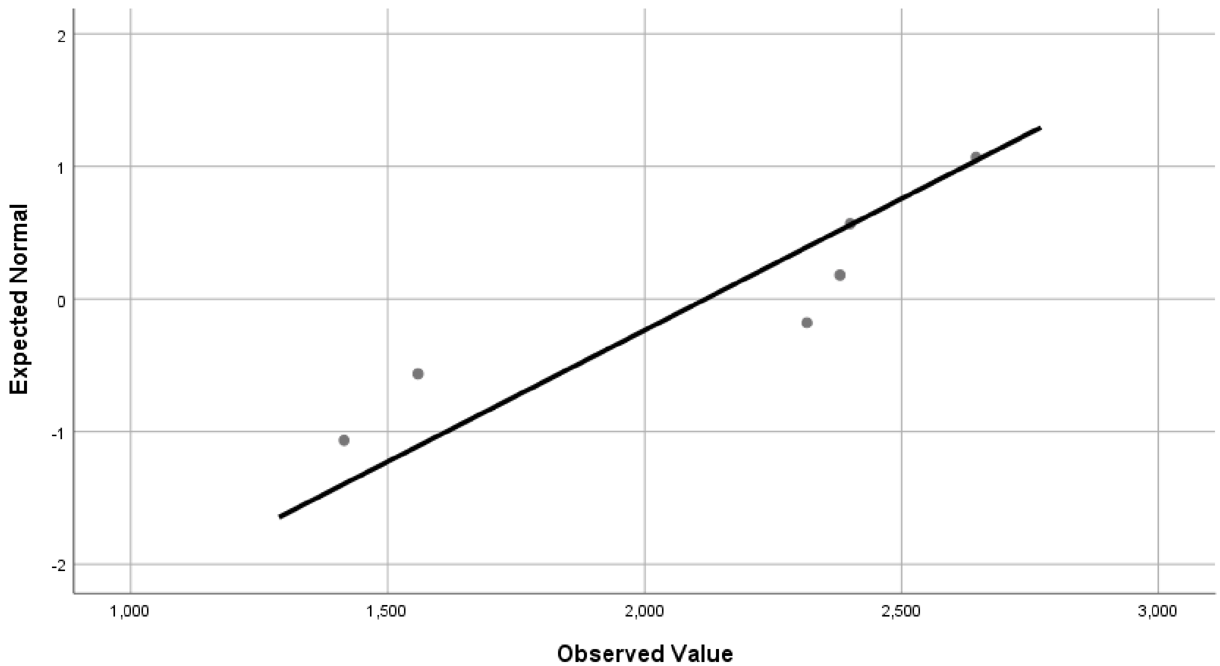


Figure 2.63

Normal P-P Plot of Regression Standardized Residual for Non-Science and Engineering Fields

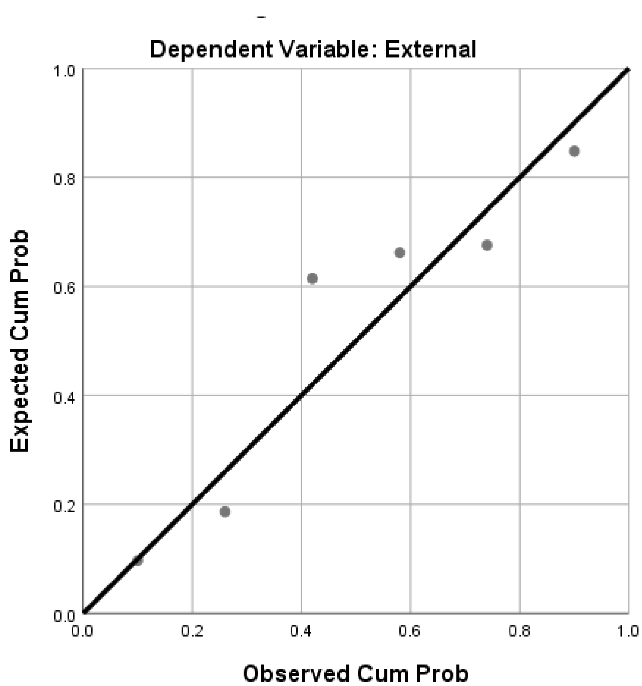
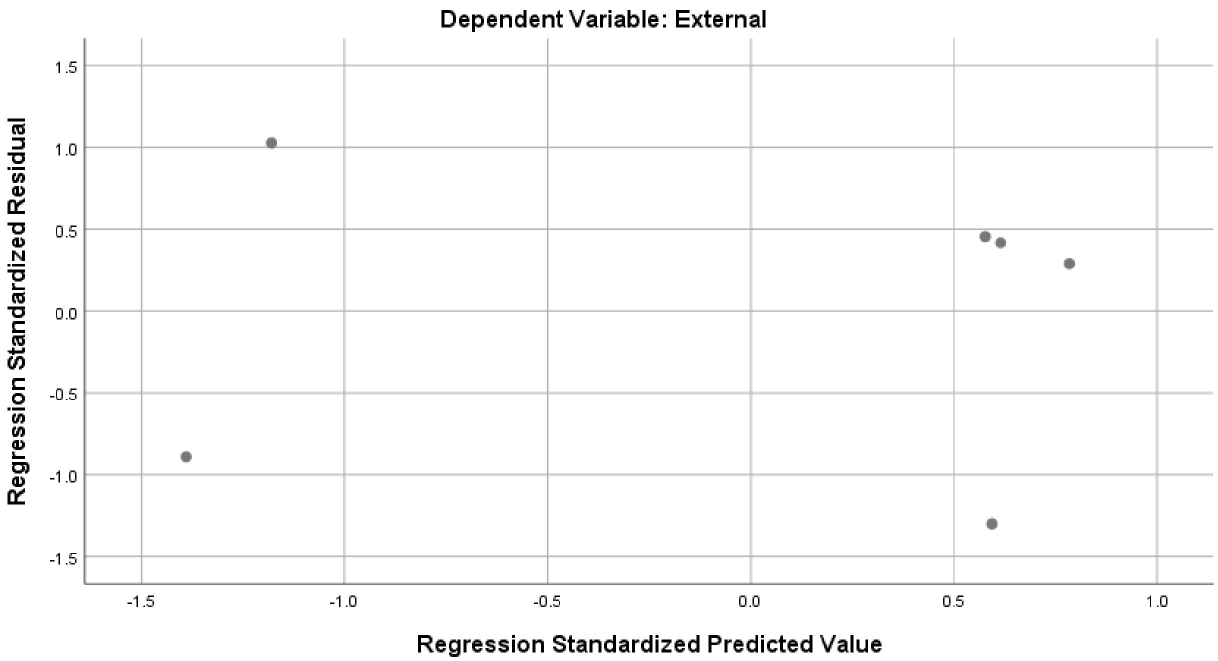


Figure 2.64

Scatterplot for Non-Science and Engineering Fields



Communication and Communications Technologies

Table 2.17 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Communication and Communications (C&C) Technologies R&D expenditures. Figure 2.65 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Communication and Communication Technologies subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.66. Standardized residuals were not normally distributed as shown in Figure 2.67. Scatterplots in Figure 2.68 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures, $F(1,4) = .55$, $p = .500$.

A small effect size was noted with approximately 12.1% of the variances accounted for in the model, $R^2 = .121$.

Table 2.17

Descriptive Statistics for C&C Technologies (n = 6 and r = 0.35)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	0	90
2016	2	525
2017	15	631
2018	61	681
2019	68	727
2020	52	91
M	33.00	457.50
SD	30.80	292.10

Figure 2.65

Scatter Plot of External by Institutional for C&C Technologies

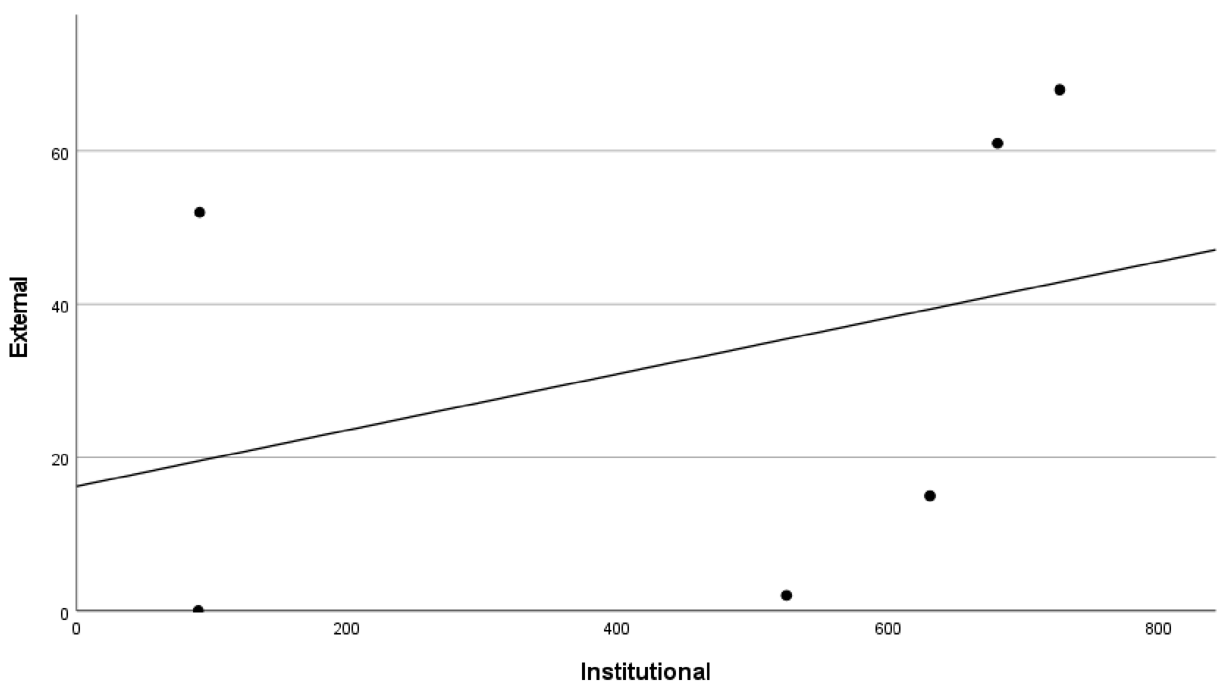


Figure 2.66

Normal Q-Q Plot of External for C&C Technologies

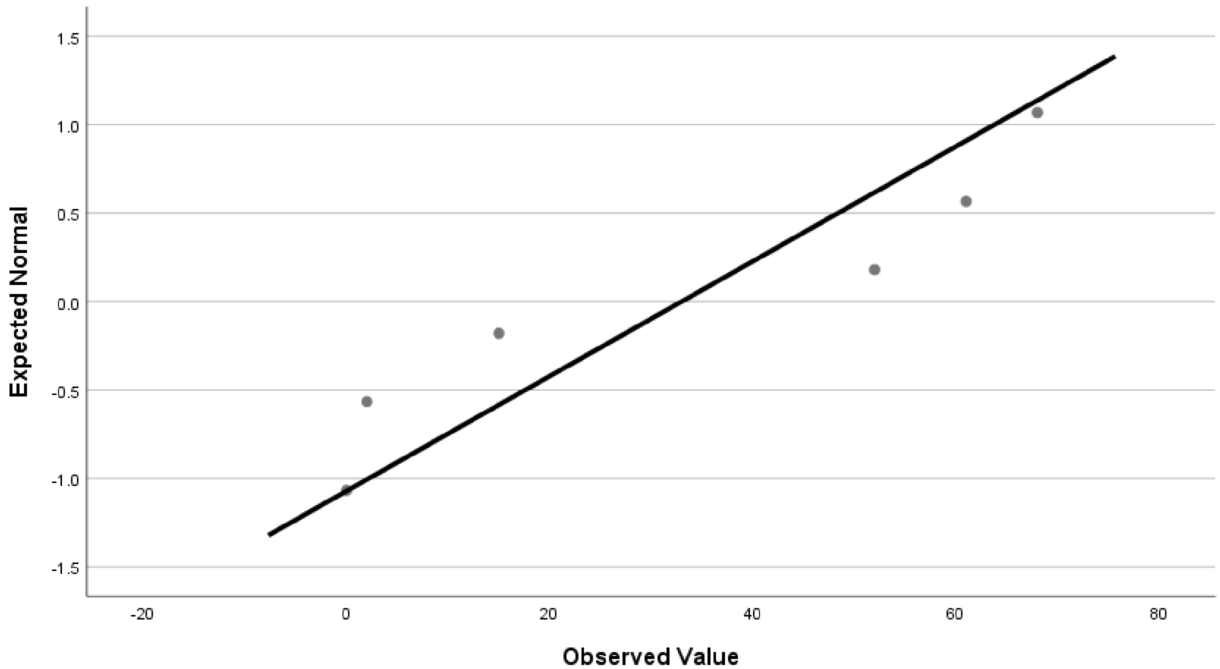


Figure 2.67

Normal P-P Plot of Regression Standardized Residual for C&C Technologies

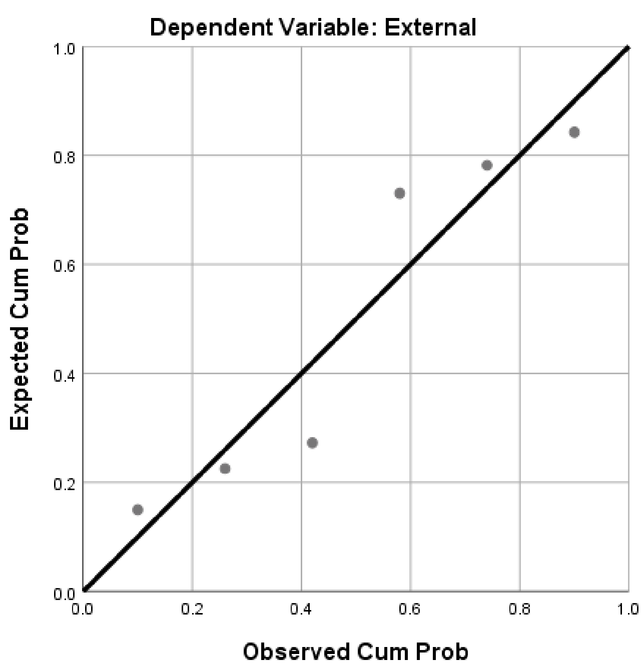
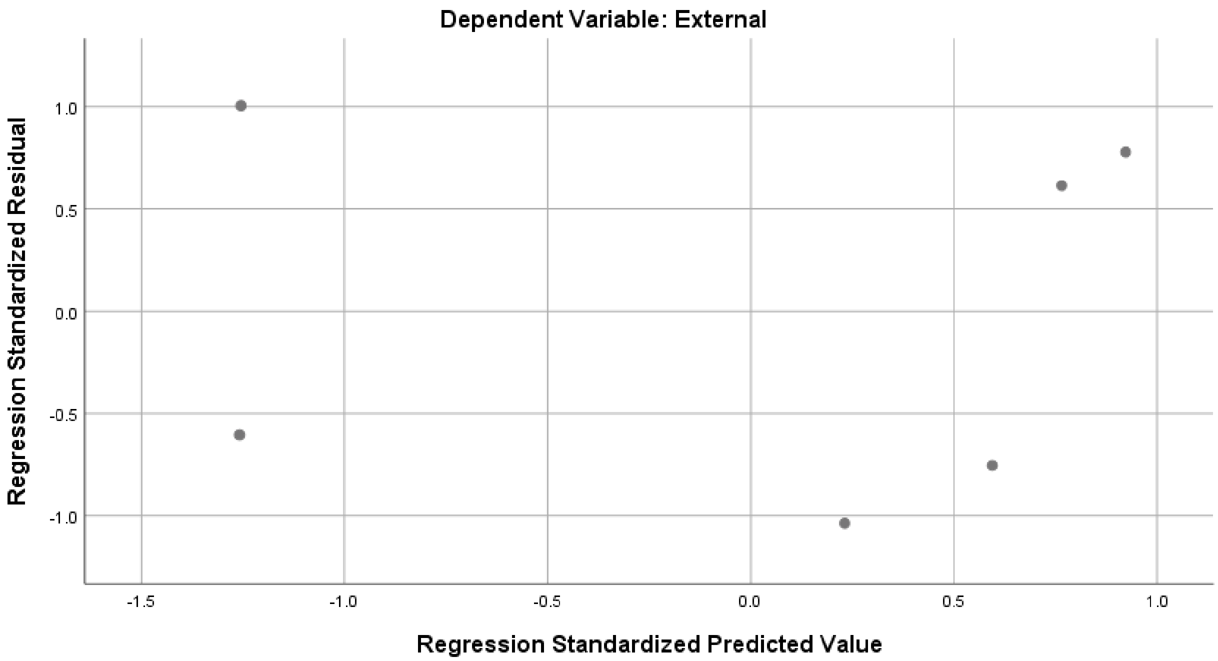


Figure 2.68

Scatterplot for C&C Technologies



Education

Table 2.18 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Education R&D expenditures. Figure 2.69 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Education subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.70. Standardized residuals were normally distributed as shown in Figure 2.71 as the values fall closely along the line. Scatterplots in Figure 2.72 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Education subfield, $F(1,4) = .51, p = .513$. A small effect size was noted with approximately 11.4% of the variances accounted for in the model, $R^2 = .114$.

Table 2.18

Descriptive Statistics for Education (n = 6 and r = -0.34)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	218	273
2016	257	1305
2017	302	1444
2018	447	1631
2019	378	1508
2020	852	339
M	409.00	1083.33
SD	232.25	611.58

Figure 2.69

Scatter Plot of External by Institutional for Education

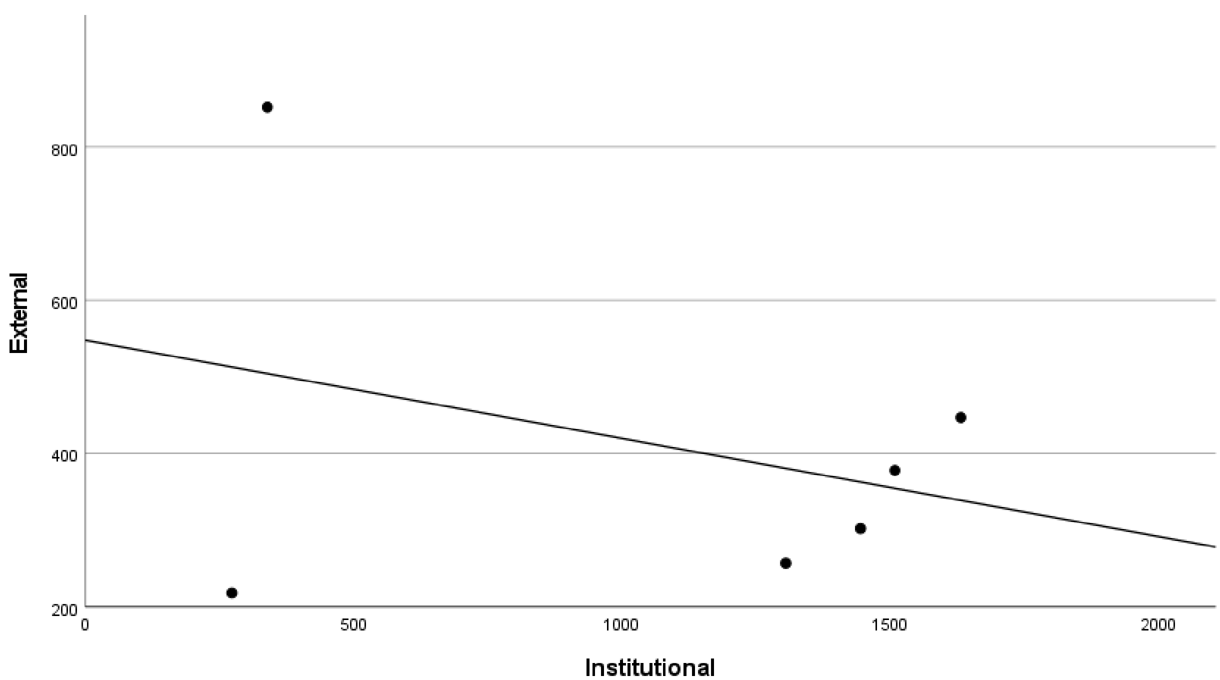


Figure 2.70

Normal Q-Q Plot of External for Education

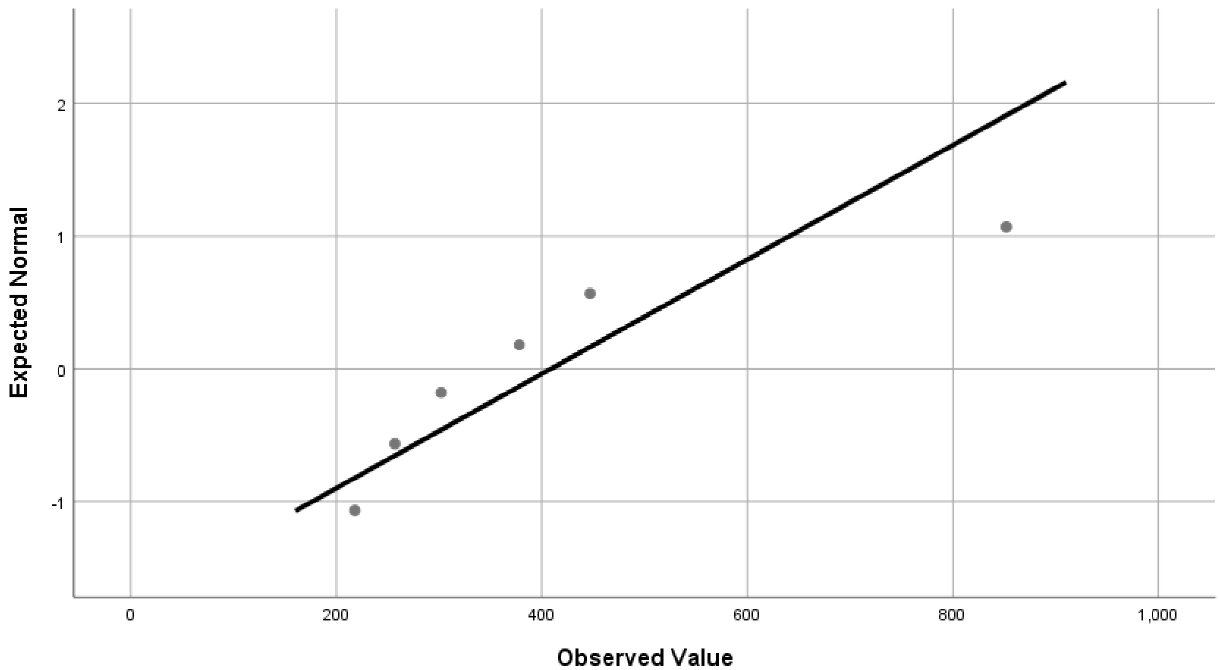


Figure 2.71

Normal P-P Plot of Regression Standardized Residual for Education

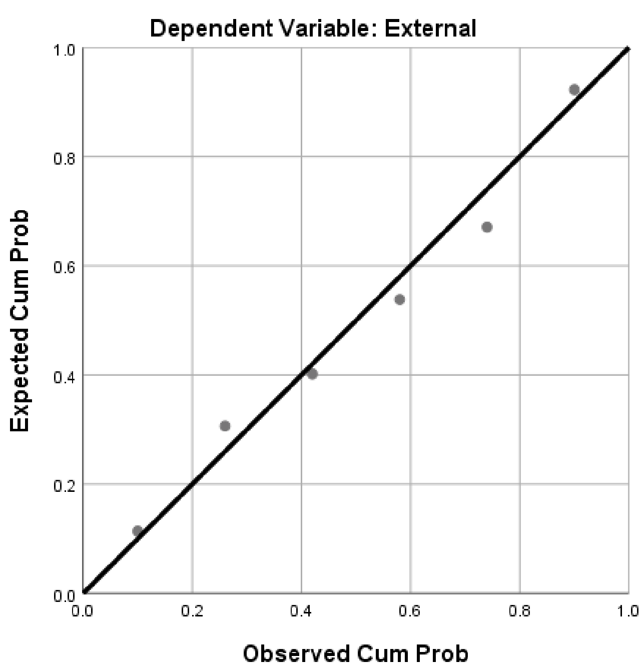
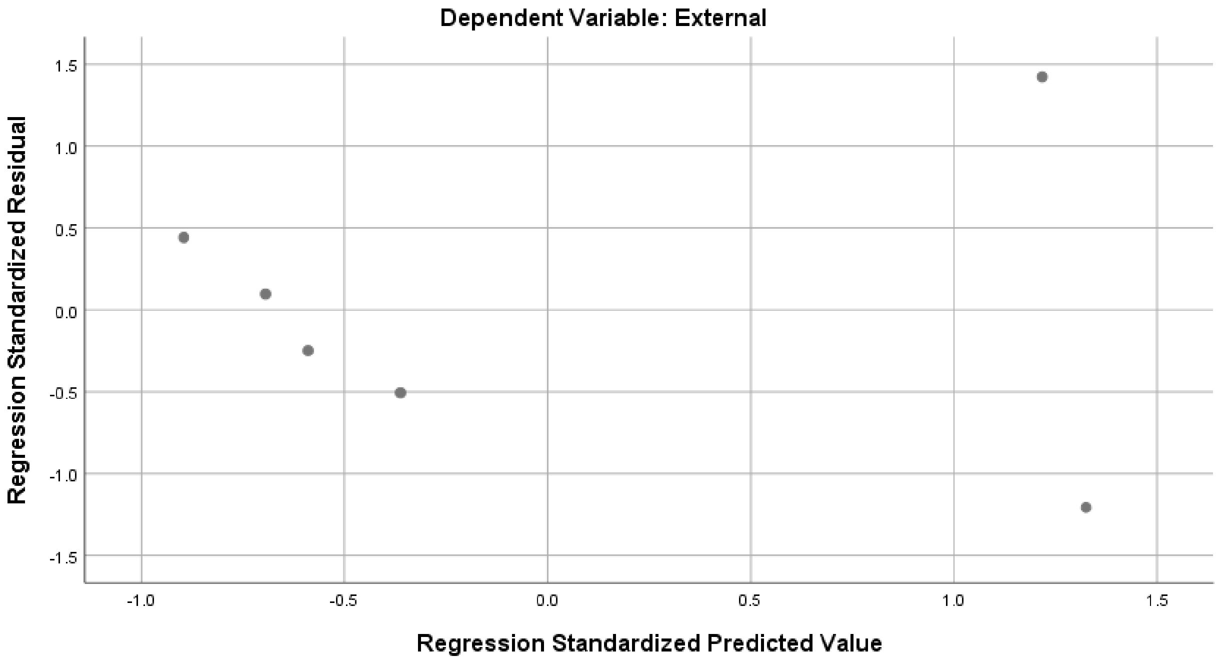


Figure 2.72

Scatterplot for Education



Humanities

Table 2.19 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Humanities R&D expenditures. Figure 2.73 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Humanities subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.74. Standardized residuals were normally distributed as shown in Figure 2.75 as most values fall closely along the line. Scatterplots in Figure 2.76 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Humanities subfield, $F(1,4) = 3.46$, $p = .136$. A large effect size was noted with approximately 46.4% of the variances accounted for in the model, $R^2 = .464$.

Table 2.19

Descriptive Statistics for Humanities (n = 6 and r = 0.68)

	R&D Expenditures (Dollars in thousands)	
Fiscal Year	Externally Funded	Institutionally Funded
2015	17	1003
2016	40	5217
2017	88	5261
2018	125	4746
2019	171	5582
2020	50	1777
M	81.83	3931.00
SD	58.00	2001.28

Figure 2.73

Scatter Plot of External by Institutional for Humanities

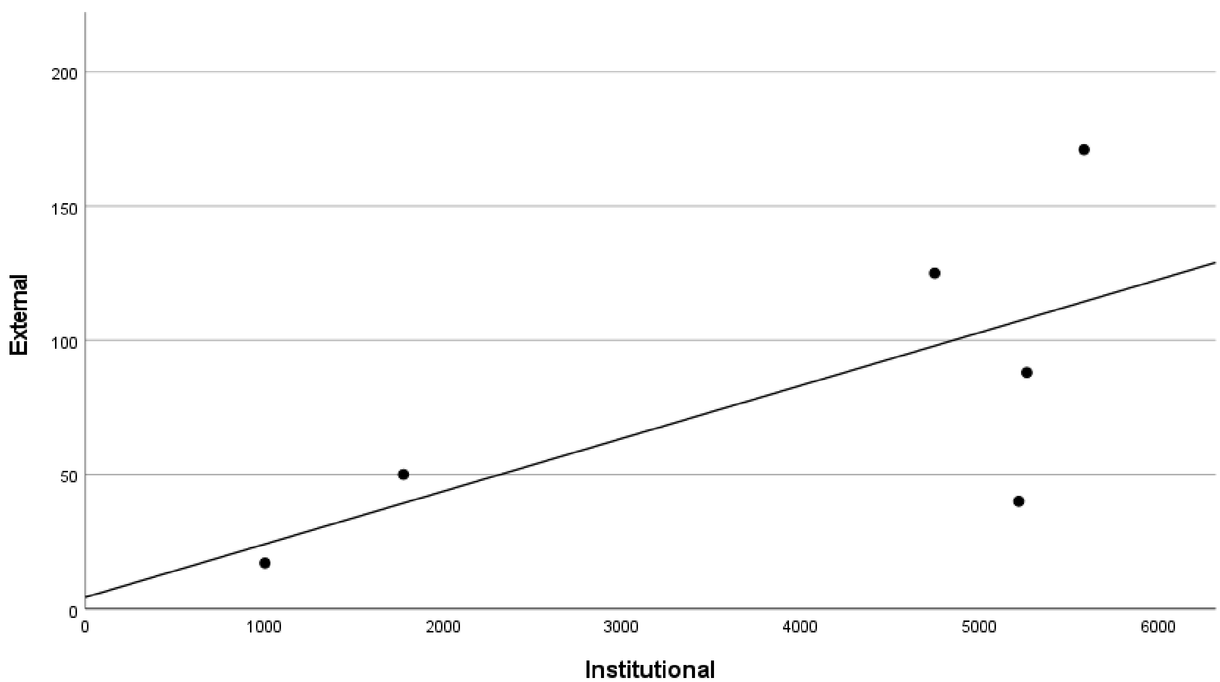


Figure 2.74

Normal Q-Q Plot of External for Humanities

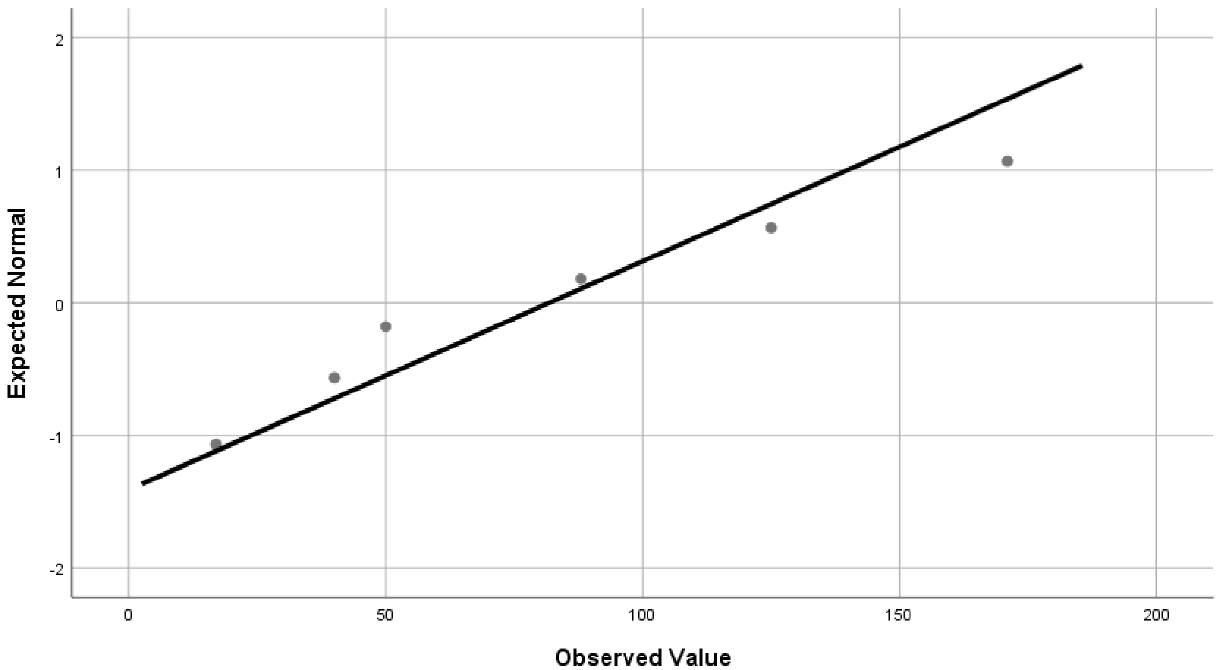


Figure 2.75

Normal P-P Plot of Regression Standardized Residual for Humanities

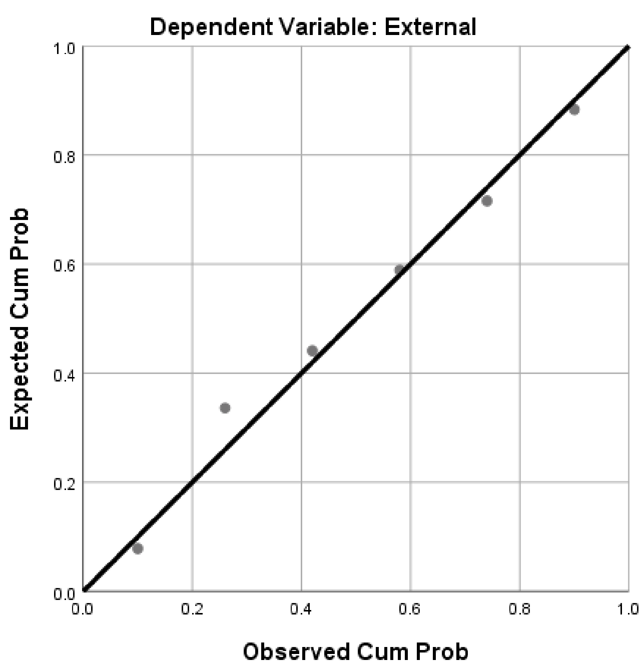
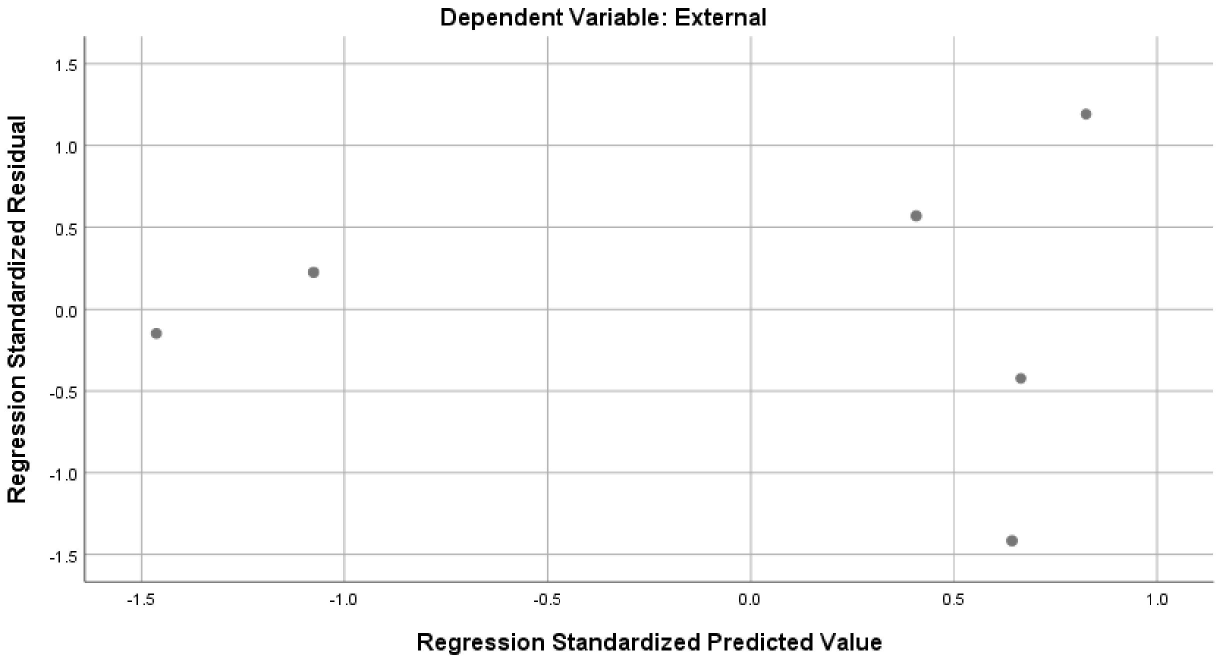


Figure 2.76

Scatterplot for Humanities



Law

Table 2.20 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Law R&D expenditures. Figure 2.77 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Law subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.78. Standardized residuals were not normally distributed as shown in Figure 2.79. Scatterplots in Figure 2.80 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Law subfield, $F(1,4) = .05$, $p = .842$. A small effect size was noted with approximately 1.1% of the variances accounted for in the model, $R^2 = .011$.

Table 2.20

Descriptive Statistics for Law (n = 6 and r = -0.11)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	1192	393
2016	1021	2781
2017	1913	1842
2018	1707	1887
2019	1678	1749
2020	1645	371
M	1526.00	1503.83
SD	342.46	945.48

Figure 2.77

Scatter Plot of External by Institutional for Law

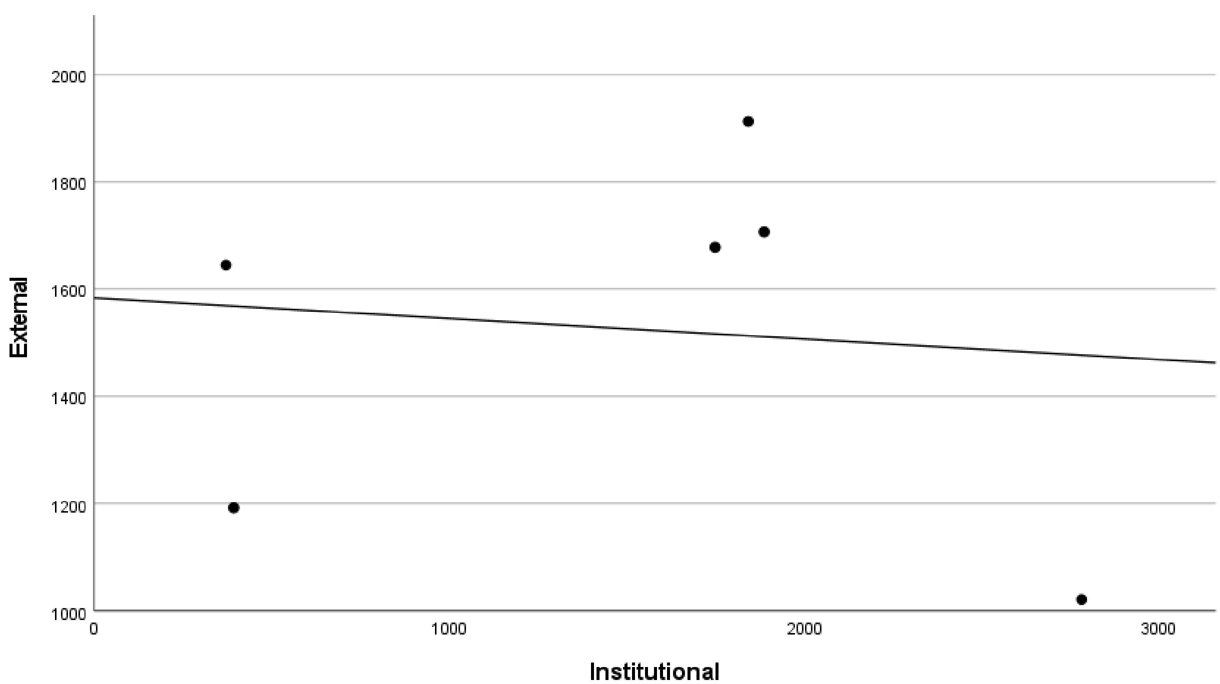


Figure 2.78

Normal Q-Q Plot of External for Law

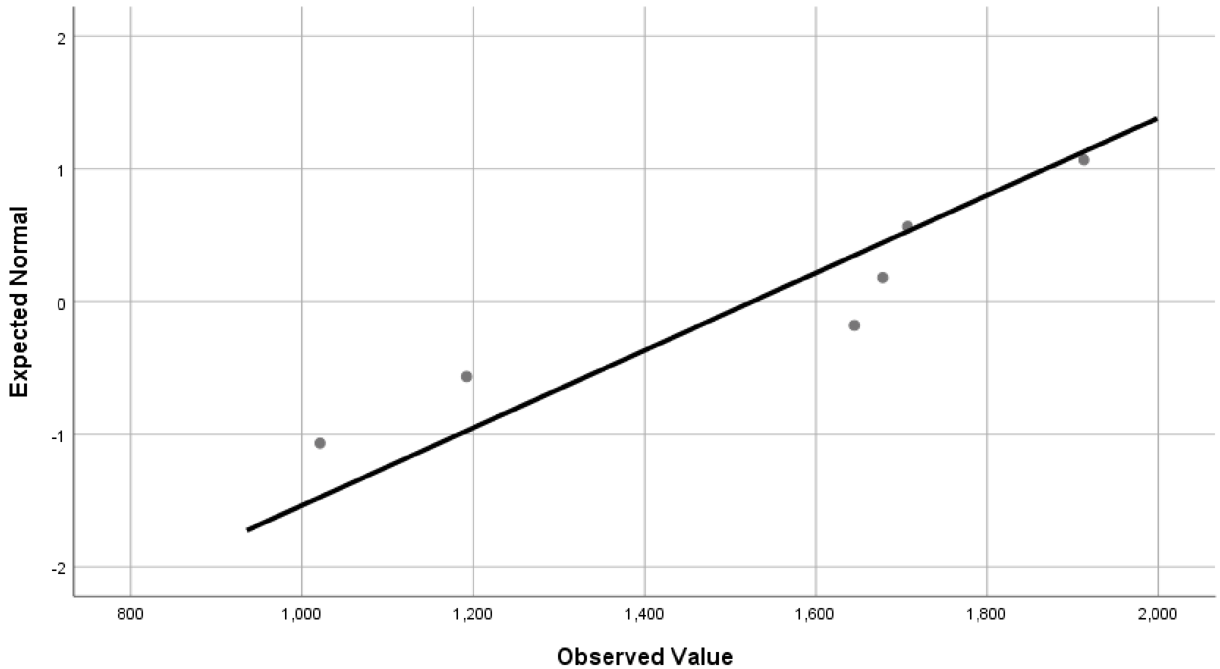


Figure 2.79

Normal P-P Plot of Regression Standardized Residual for Law

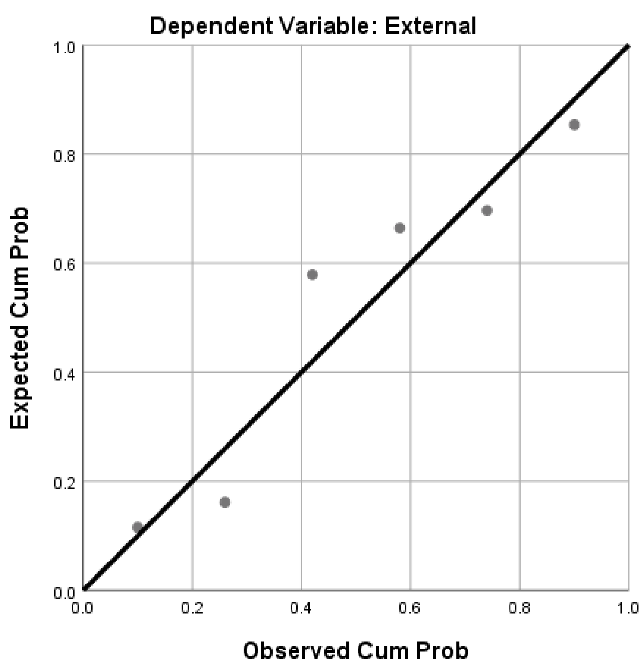
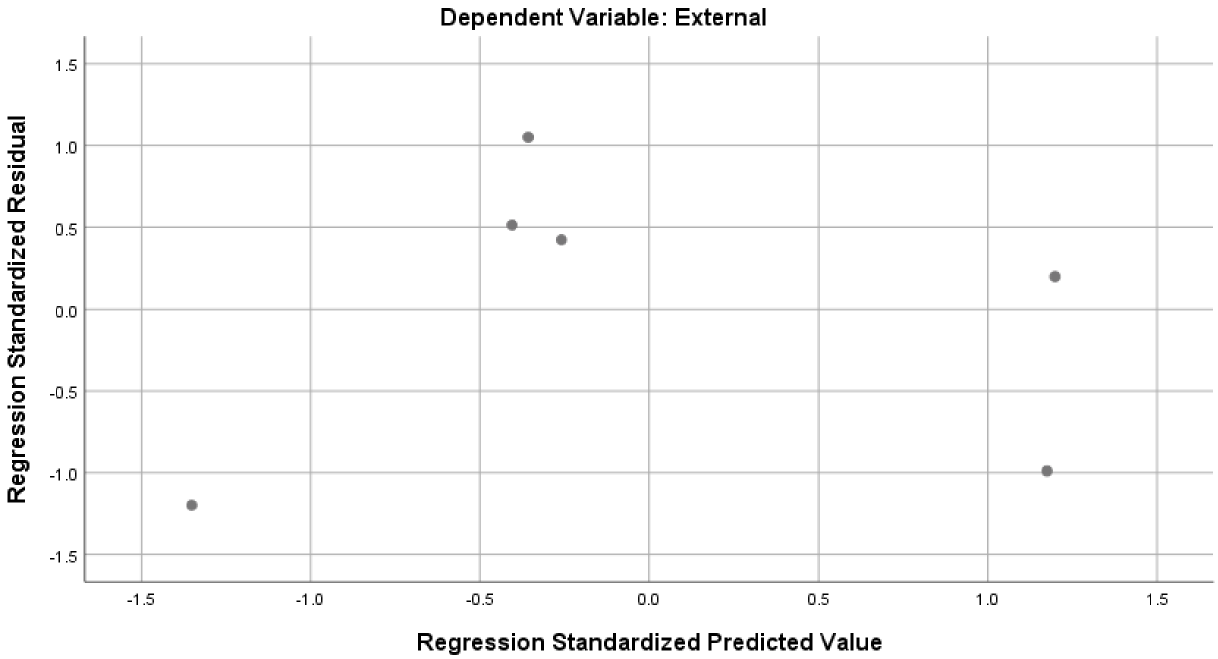


Figure 2.80

Scatterplot for Law



Social Work

Table 2.21 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Social Work R&D expenditures. Figure 2.81 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Social Work subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.82. Standardized residuals were not normally distributed as shown in Figure 2.83. Scatterplots in Figure 2.84 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Social Work subfield, $F(1,4) = .94$, $p = .386$. A medium effect size was noted with approximately 19.1% of the variances accounted for in the model, $R^2 = .191$.

Table 2.21

Descriptive Statistics for Social Work (n = 6 and r = -0.44)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	5	6
2016	6	290
2017	9	503
2018	10	622
2019	0	425
2020	38	37
M	11.33	313.83
SD	13.53	251.03

Figure 2.81

Scatter Plot of External by Institutional for Social Work

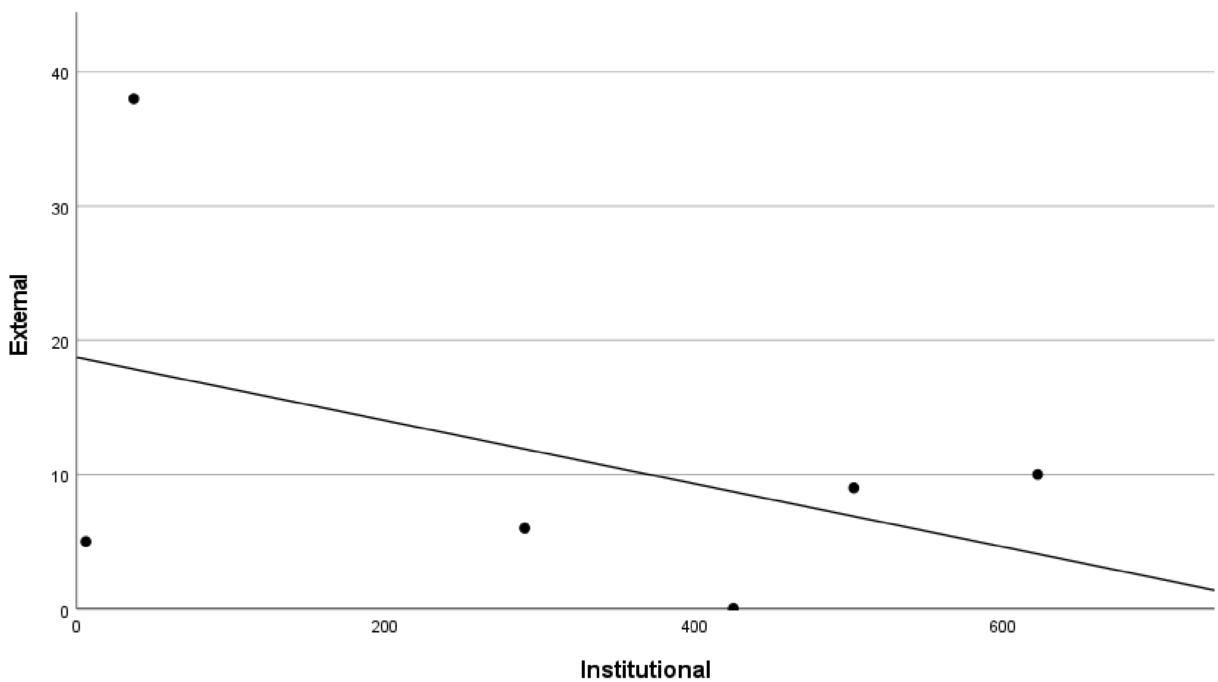


Figure 2.82

Normal Q-Q Plot of External for Social Work

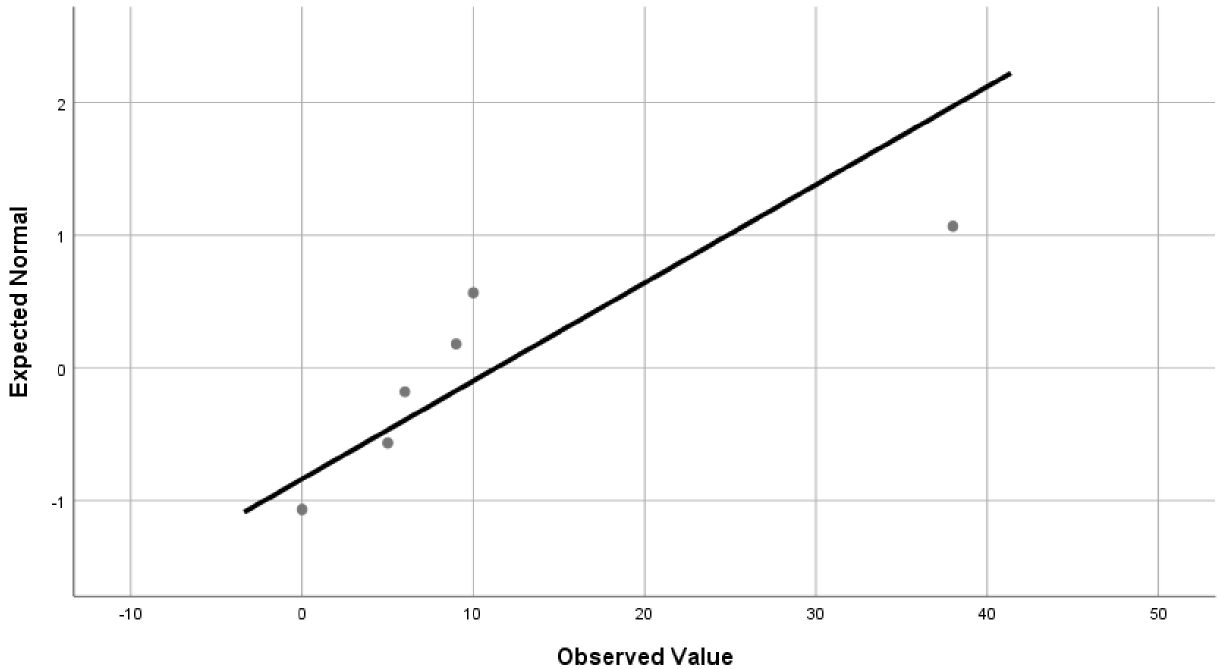


Figure 2.83

Normal P-P Plot of Regression Standardized Residual for Social Work

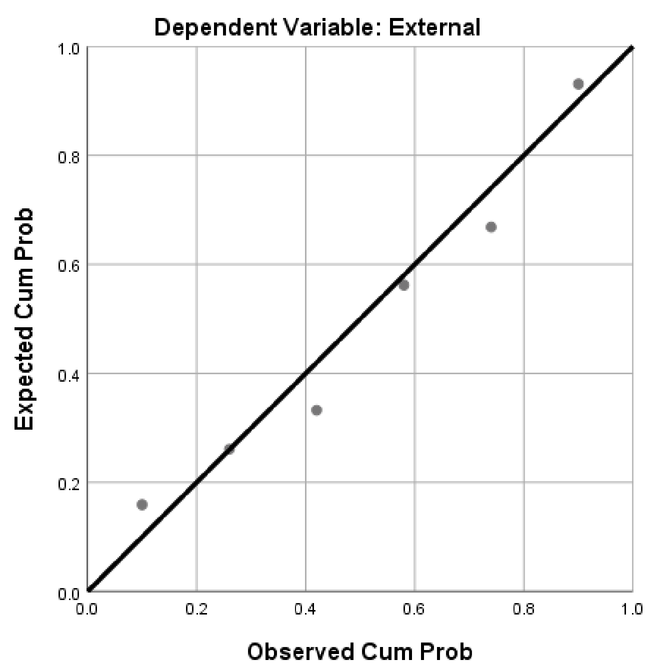
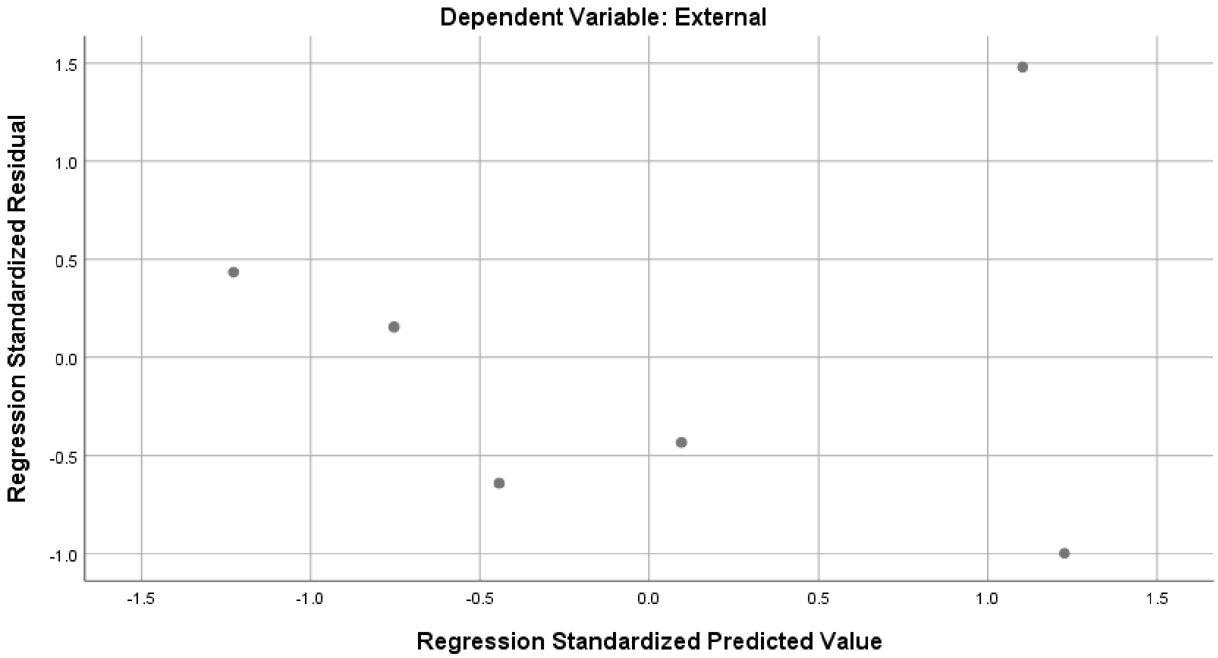


Figure 2.84

Scatterplot for Social Work



Other Non-Science and Engineering

The NSF HERD Survey (n.d.) categorizes Other Non-Science and Engineering fields that cannot be specifically identified within the previously listed subfields as Other Non-Science and Engineering. Table 2.22 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Non-Science and Engineering R&D expenditures. Figure 2.85 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Non-Science and Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.86. Standardized residuals were not normally distributed as shown in Figure 2.87. Scatterplots in Figure 2.88 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Non-Science and Engineering fields, $F(1,4) = .60$, $p = .480$. A medium effect size was noted with approximately 13.1% of the variances accounted for in the model, $R^2 = .131$.

Table 2.22

Descriptive Statistics for Other Non-Science and Engineering (n = 6 and r = -0.36)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	64	259
2016	30	1820
2017	25	1949
2018	23	1893
2019	21	2194
2020	8	374
M	28.50	1414.83
SD	18.88	860.76

Figure 2.85

Scatter Plot of External by Institutional for Other Non-Science and Engineering

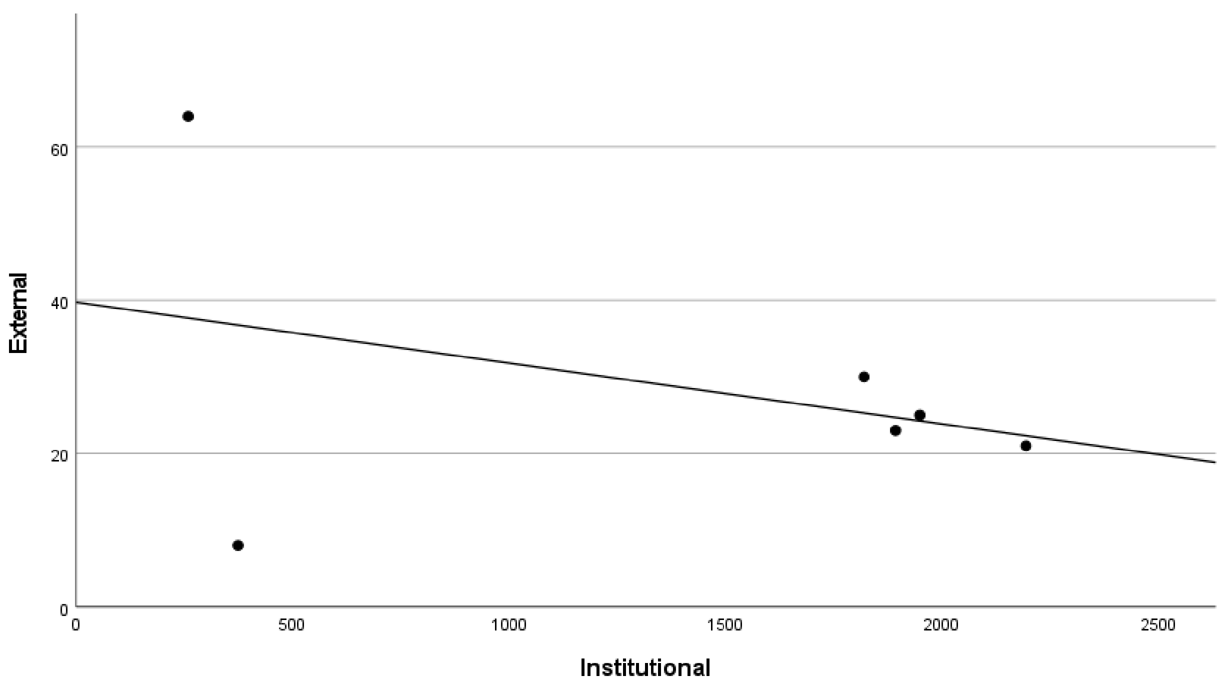


Figure 2.86

Normal Q-Q Plot of External for Other Non-Science and Engineering

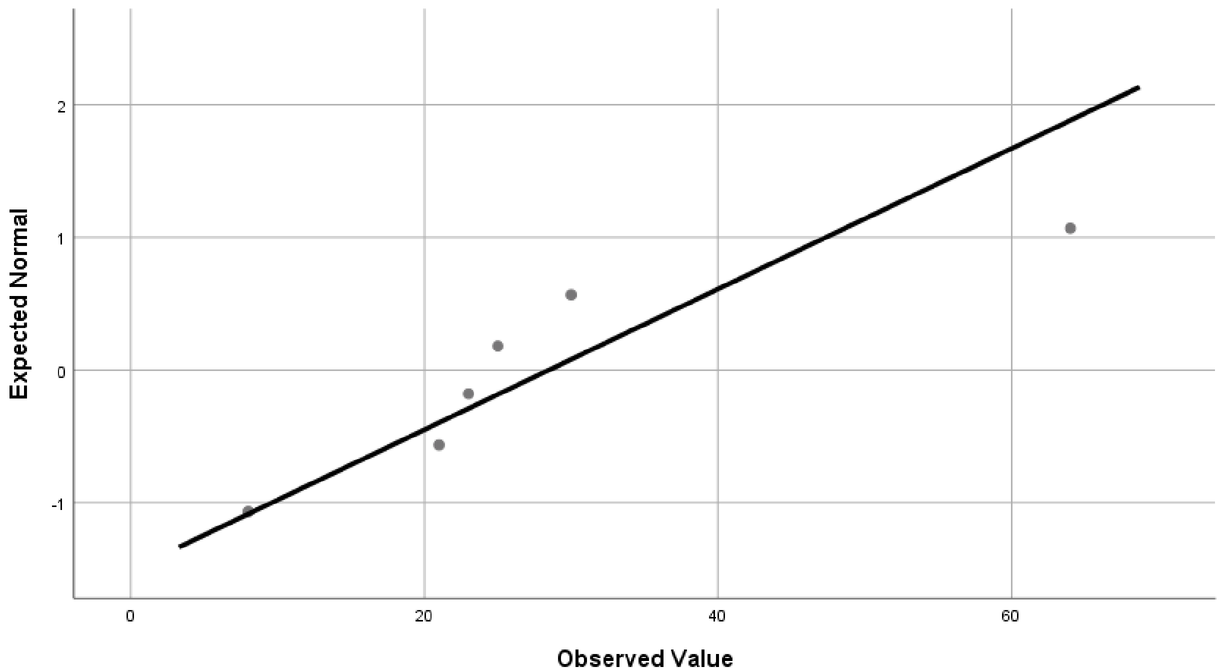


Figure 2.87

Normal P-P Plot of Regression Standardized Residual for Other Non-Science and Engineering

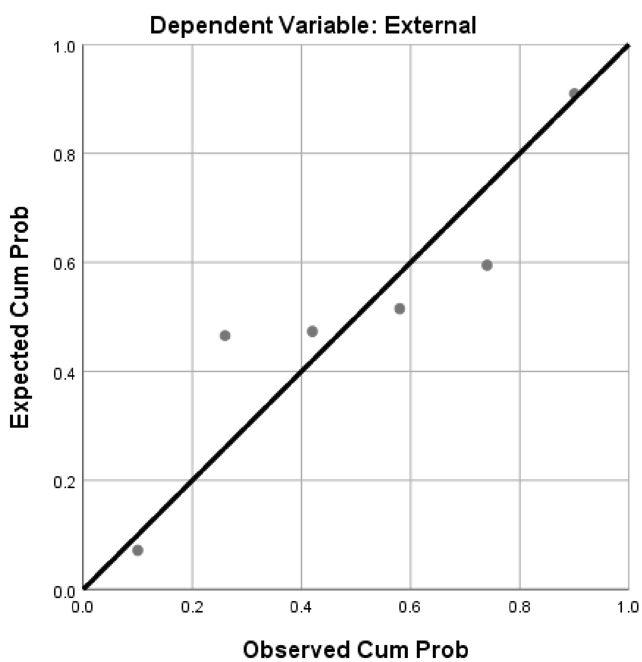
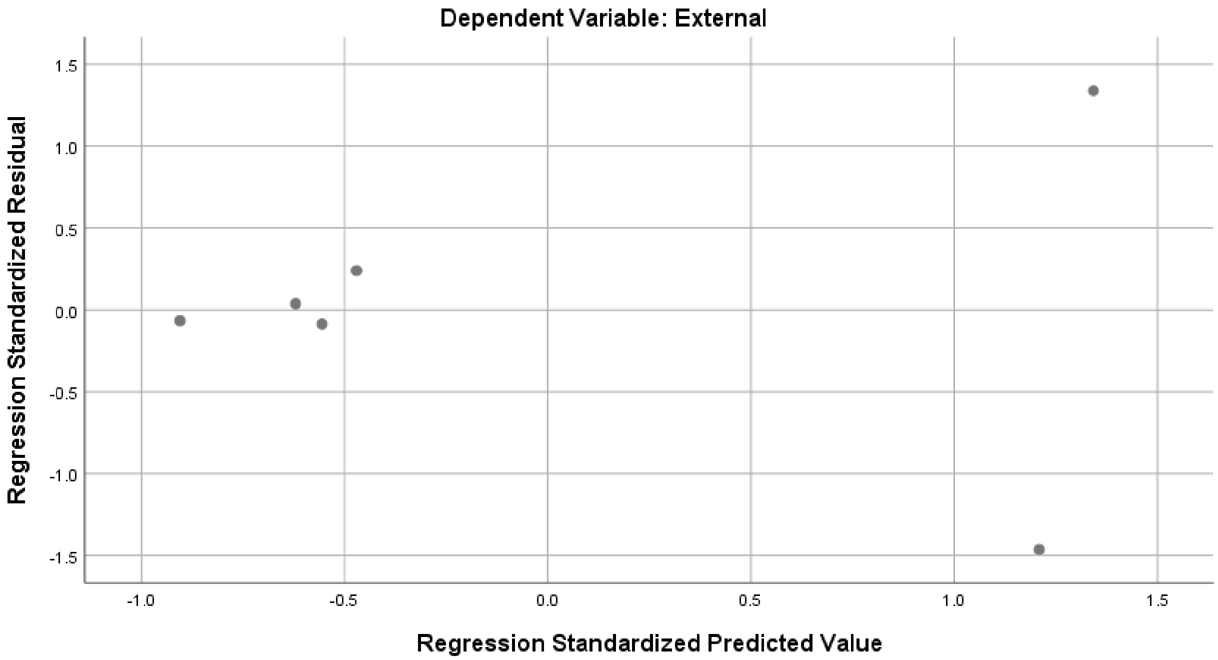


Figure 2.88

Scatterplot for Other Non-Science and Engineering



Physical Sciences

Table 2.23 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Physical Sciences R&D expenditures. Figure 2.89 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Physical Sciences field reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.90 as half of the values fall closely along the line. Standardized residuals were not normally distributed as shown in Figure 2.91. Scatterplots in Figure 2.92 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Physical Sciences field, $F(1,4) = 6.57$, $p = .062$. A large effect size was noted with approximately 62.2% of the variances accounted for in the model, $R^2 = .622$.

Table 2.23

Descriptive Statistics for Physical Sciences (n = 6 and r = 0.79)

	R&D Expenditures (Dollars in thousands)	
Fiscal Year	Externally Funded	Institutionally Funded
2015	6235	2798
2016	8142	4506
2017	8612	4994
2018	7239	3712
2019	9974	4643
2020	8208	3444
M	8068.33	4016.17
SD	1264.99	835.80

Figure 2.89

Scatter Plot of External by Institutional for Physical Sciences

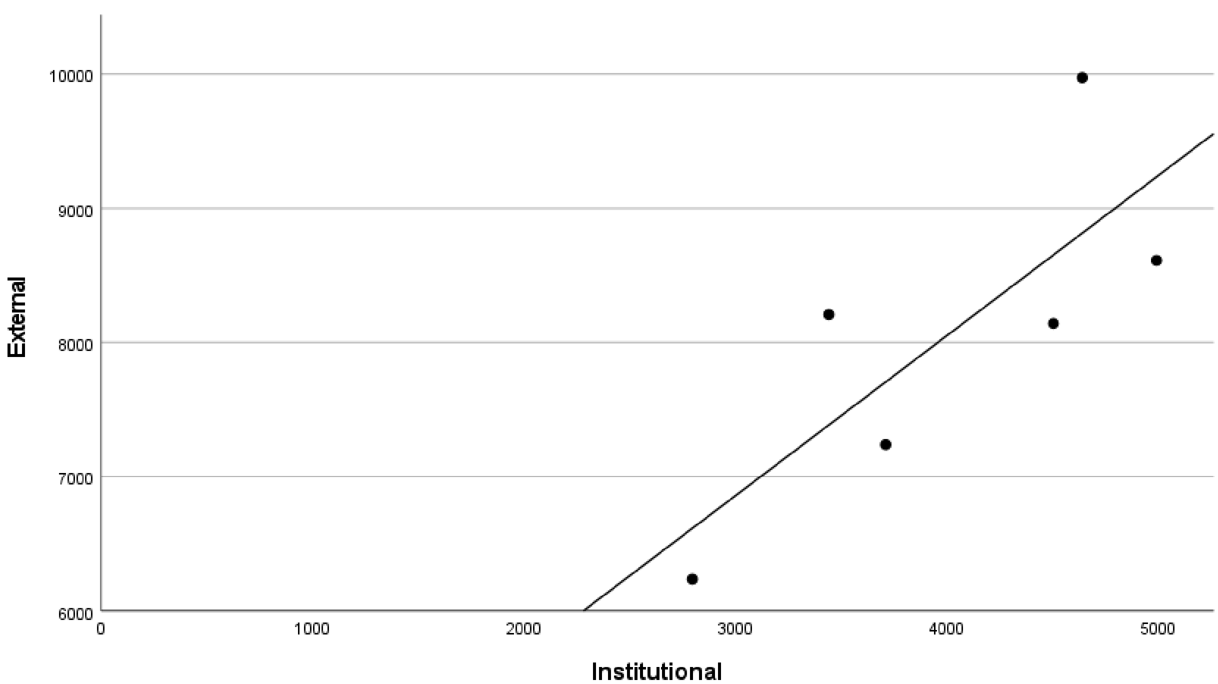


Figure 2.90

Normal Q-Q Plot of External for Physical Sciences

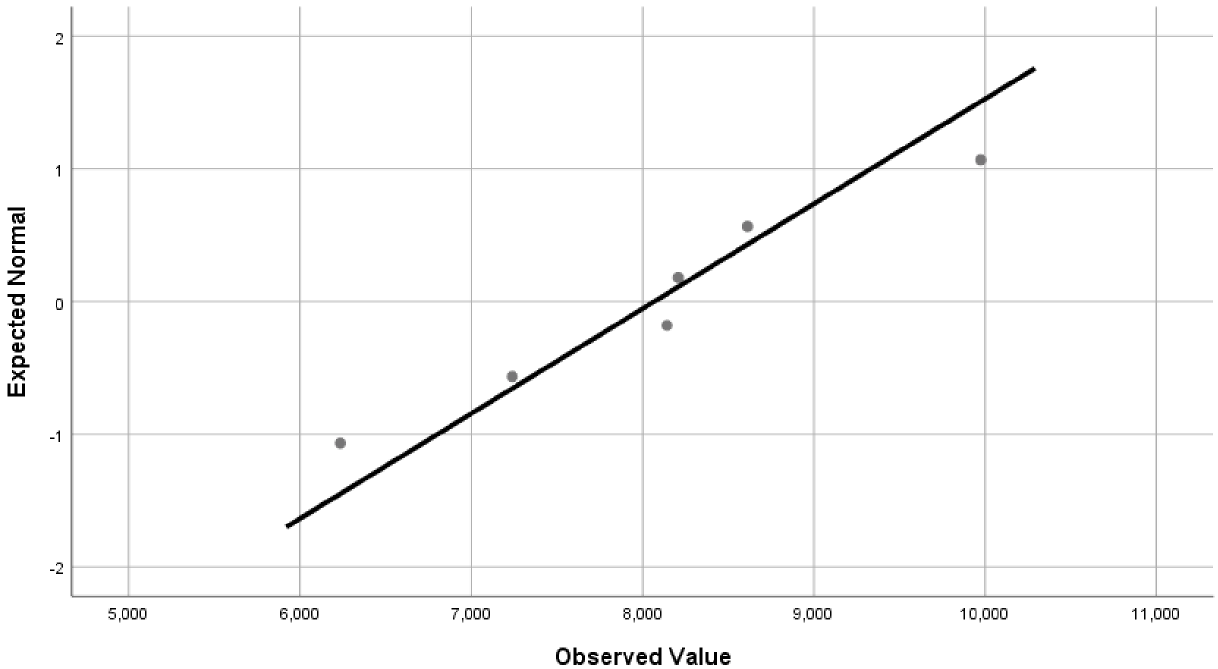


Figure 2.91

Normal P-P Plot of Regression Standardized Residual for Physical Sciences

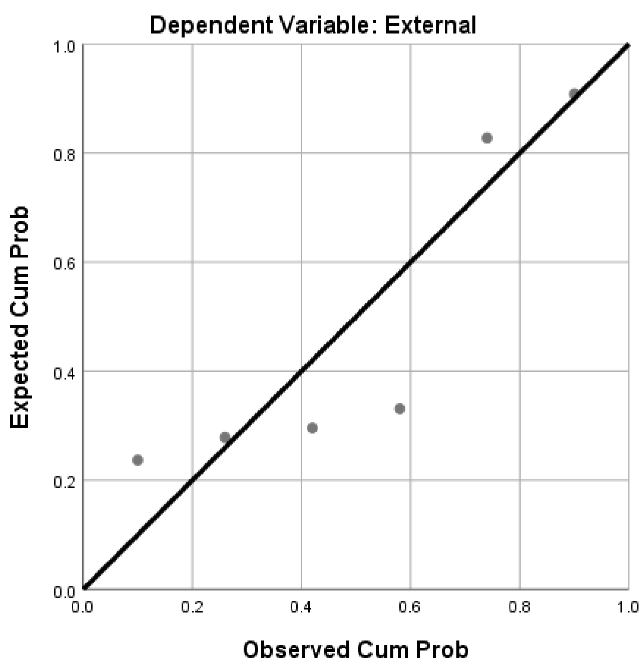
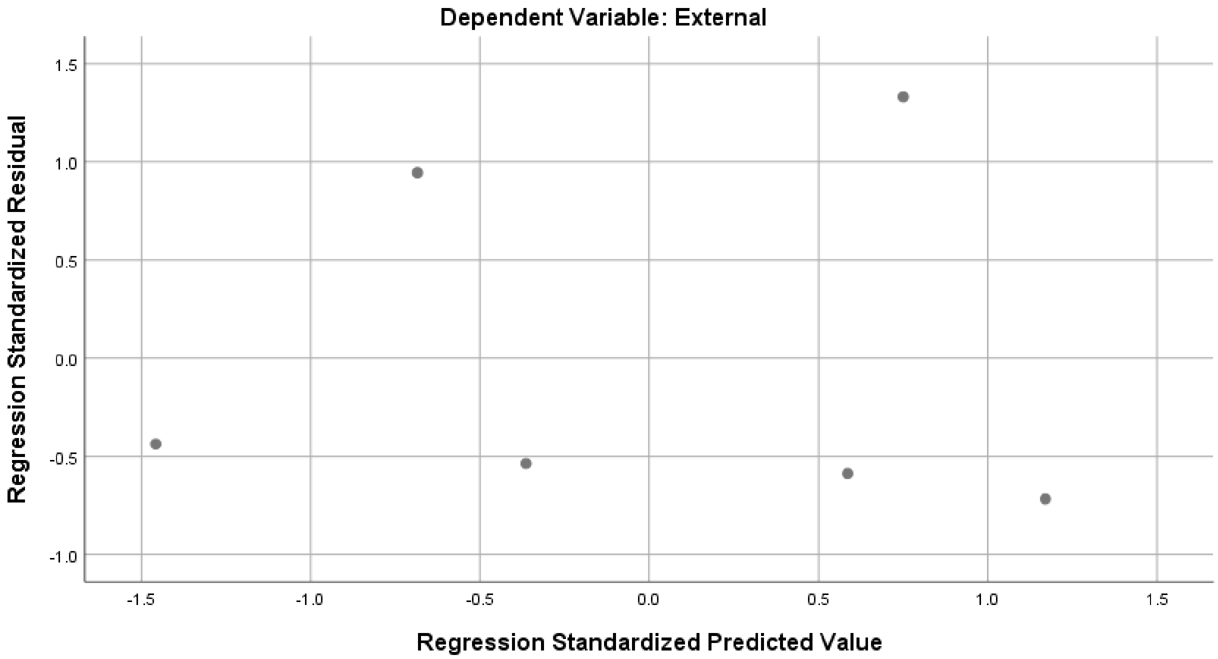


Figure 2.92

Scatterplot for Physical Sciences



Chemistry

Table 2.24 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Chemistry R&D expenditures. Figure 2.93 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Chemistry subfield reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.94 as half of the values fall closely on the line. Standardized residuals were somewhat normally distributed as shown in Figure 2.95. Scatterplots in Figure 2.96 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Chemistry subfield, $F(1,4) = 4.51$,

p = .101. A large effect size was noted with approximately 53.0% of the variances accounted for in the model, R^2 = .530.

Table 2.24

Descriptive Statistics for Chemistry (n = 6 and r = 0.73)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	1438	553
2016	1861	1716
2017	2397	2413
2018	2178	1421
2019	3939	2317
2020	2261	1733
M	2345.67	1692.17
SD	852.69	675.79

Figure 2.93

Scatter Plot of External by Institutional for Chemistry

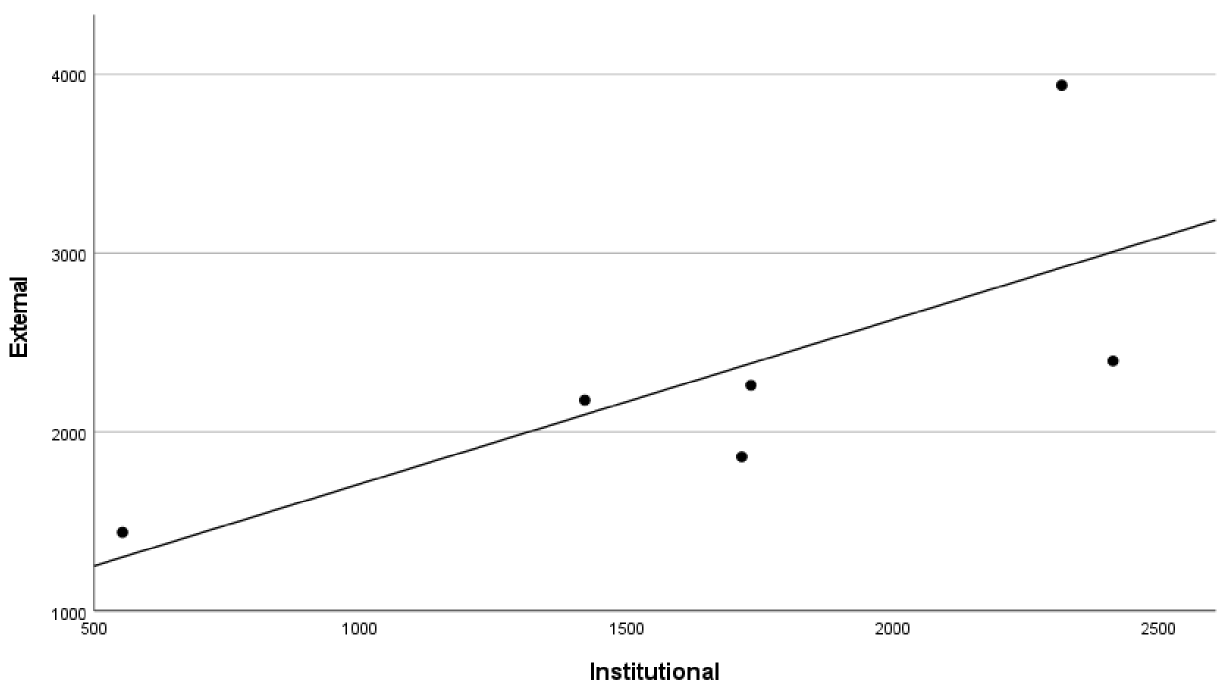


Figure 2.94

Normal Q-Q Plot of External for Chemistry

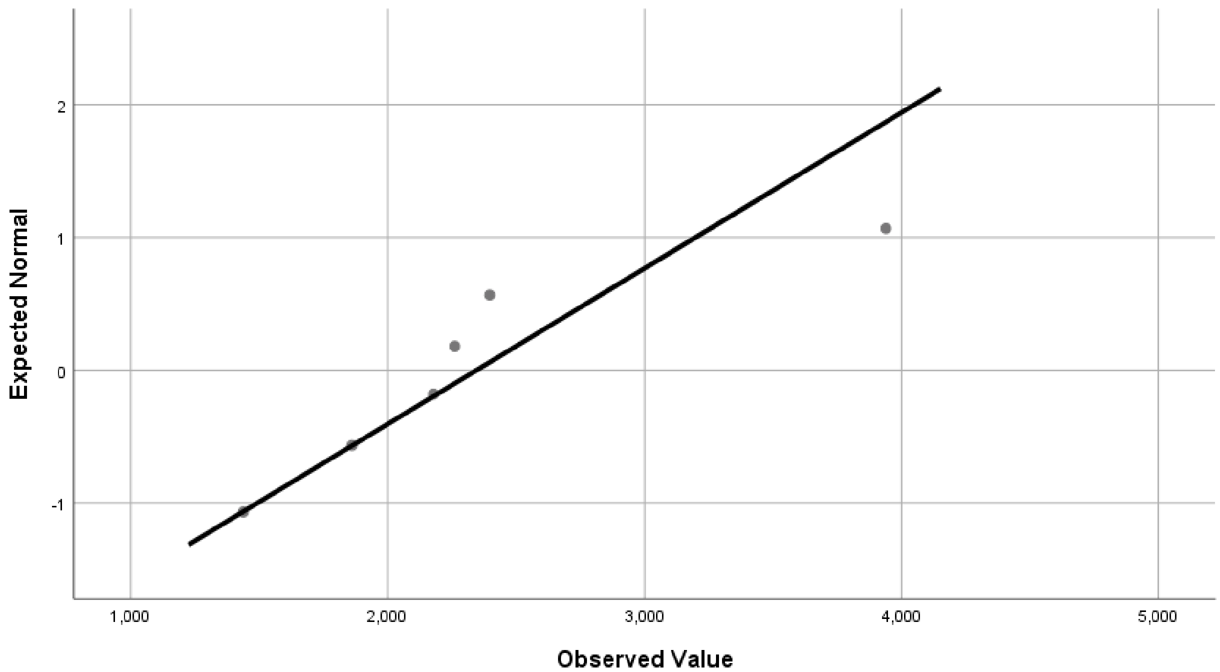


Figure 2.95

Normal P-P Plot of Regression Standardized Residual for Chemistry

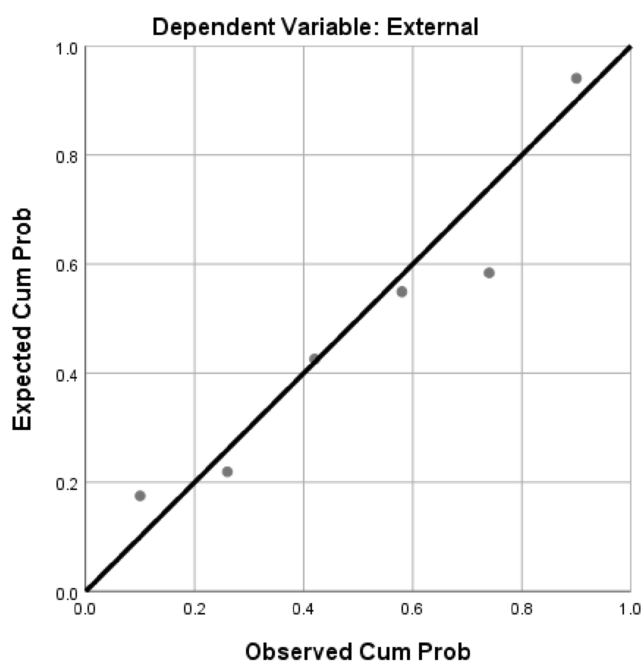
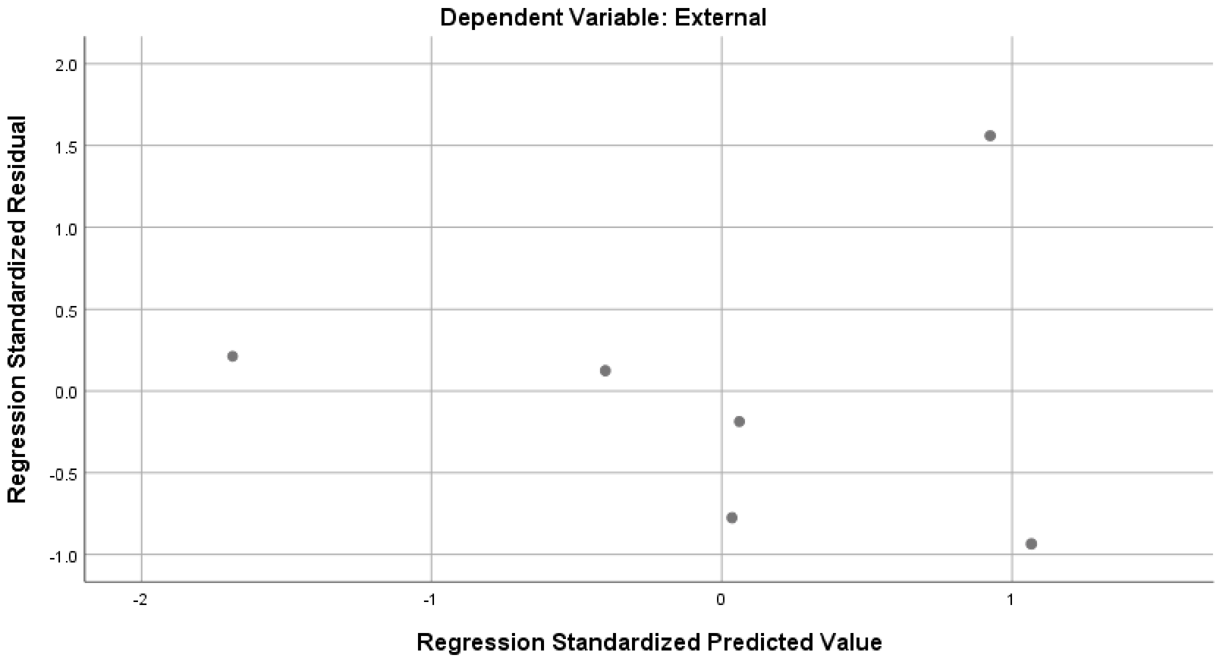


Figure 2.96

Scatterplot for Chemistry



Physics

Table 2.25 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Physics R&D expenditures. Figure 2.97 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Physics subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.98. Standardized residuals were not normally distributed as shown in Figure 2.99. Scatterplots in Figure 2.100 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Physics subfield, $F(1,4) = .39$, $p =.565$. A small effect size was noted with approximately 8.9% of the variances accounted for in the model, $R^2 = .089$.

Table 2.25

Descriptive Statistics for Physics (n = 6 and r = 0.30)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	4797	2245
2016	6281	2790
2017	6215	2581
2018	5058	2291
2019	6035	2326
2020	5947	1711
M	5722.17	2324.00
SD	632.56	365.05

Figure 2.97

Scatter Plot of External by Institutional for Physics

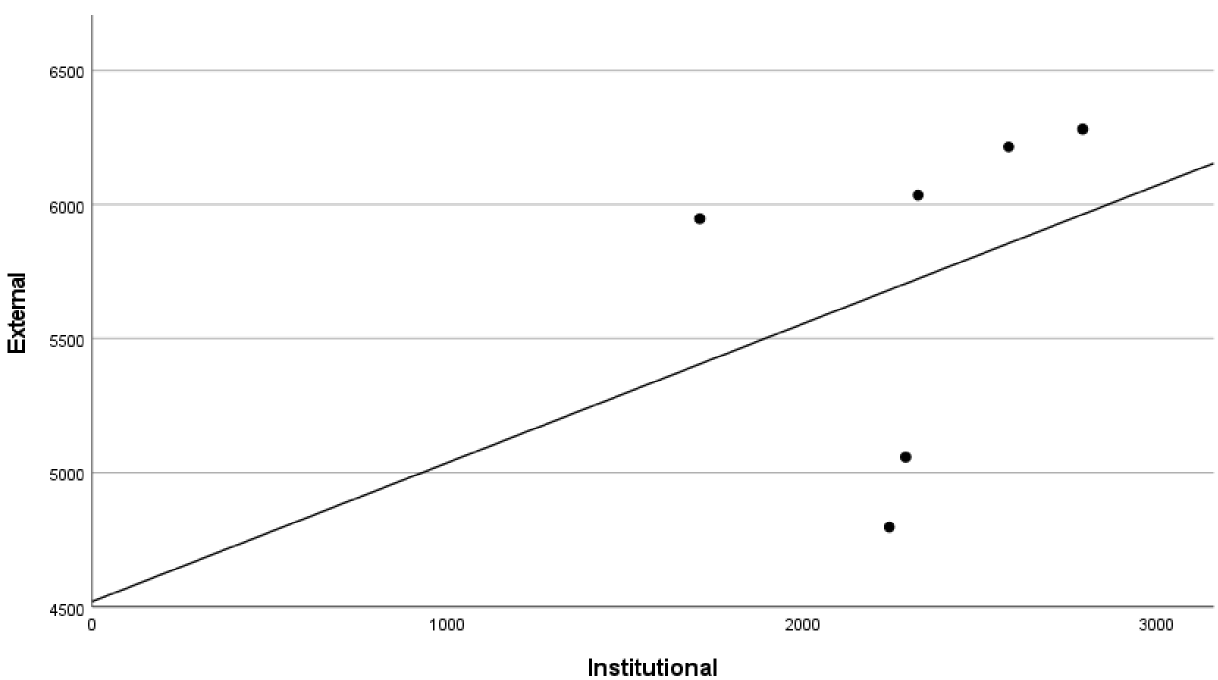


Figure 2.98

Normal Q-Q Plot of External for Physics

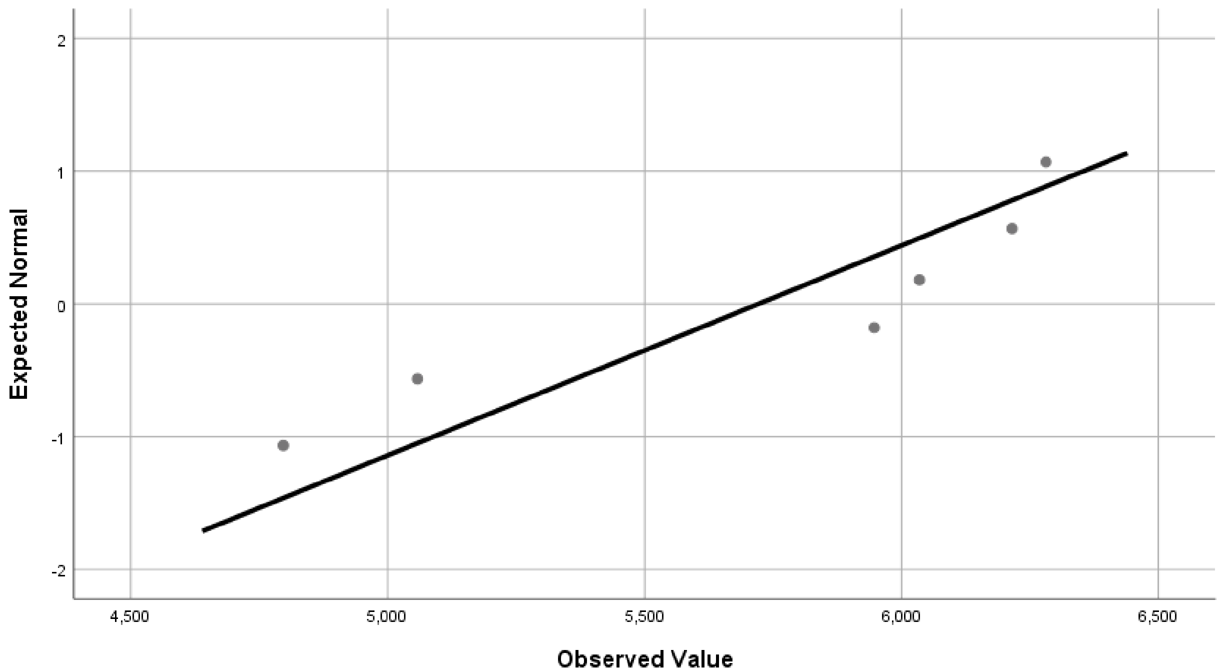


Figure 2.99

Normal P-P Plot of Regression Standardized Residual for Physics

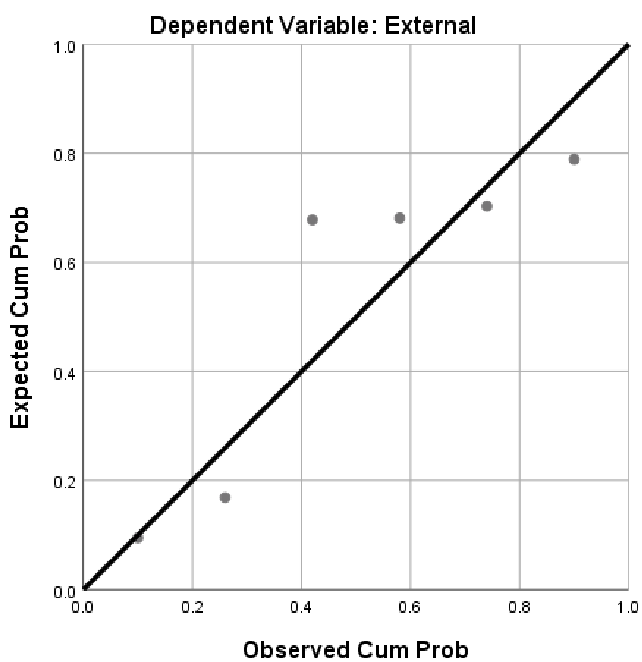
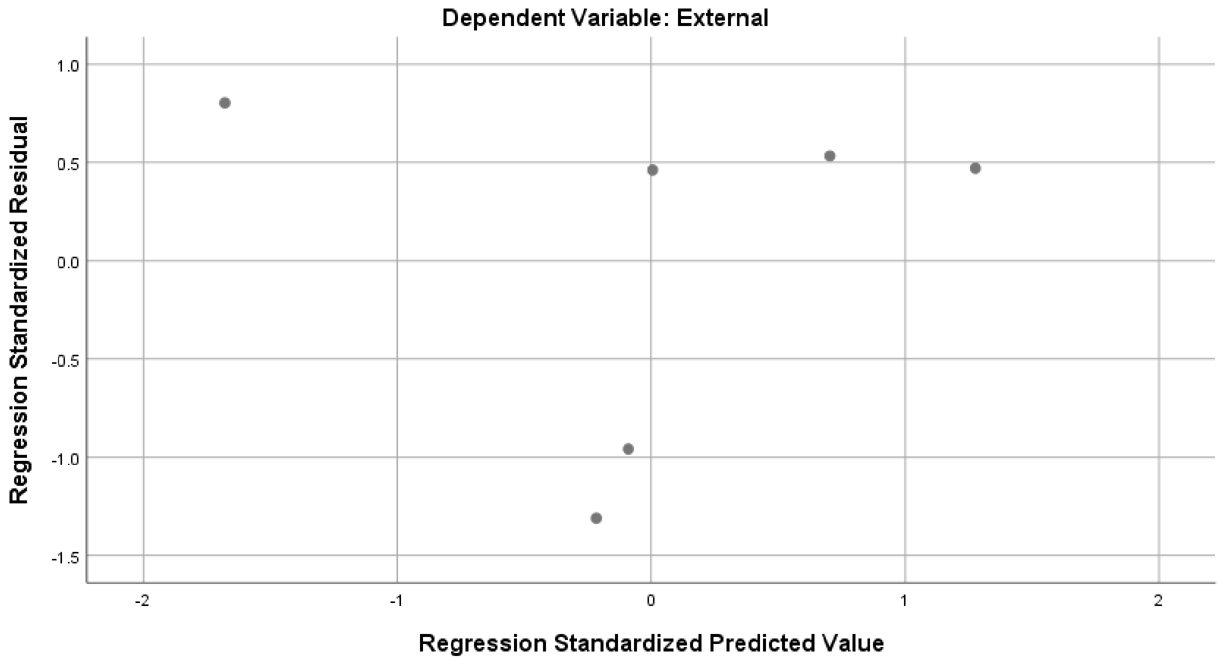


Figure 2.100

Scatterplot for Physics



Psychology

Table 2.26 details expenditures, mean (*M)*, and standard deviation (*SD*) for externally and institutionally funded Psychology R&D expenditures. Figure 2.101 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Psychology field reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.102. Standardized residuals were normally distributed as shown in Figure 2.103 as most values fall closely along the line. Scatterplots in Figure 2.104 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Psychology field, $F(1,4) = .77$, $p = .429$. A medium effect size was noted with approximately 16.2% of the variances accounted for in the model, $R^2 = .162$.

Table 2.26

Descriptive Statistics for Psychology (n = 6 and r = 0.40)

	R&D Expenditures (Dollars in thousands)	
Fiscal Year	Externally Funded	Institutionally Funded
2015	0	388
2016	33	993
2017	70	1142
2018	27	1265
2019	4	1136
2020	32	588
M	27.67	918.67
SD	25.161	350.30

Figure 2.101

Scatter Plot of External by Institutional for Psychology

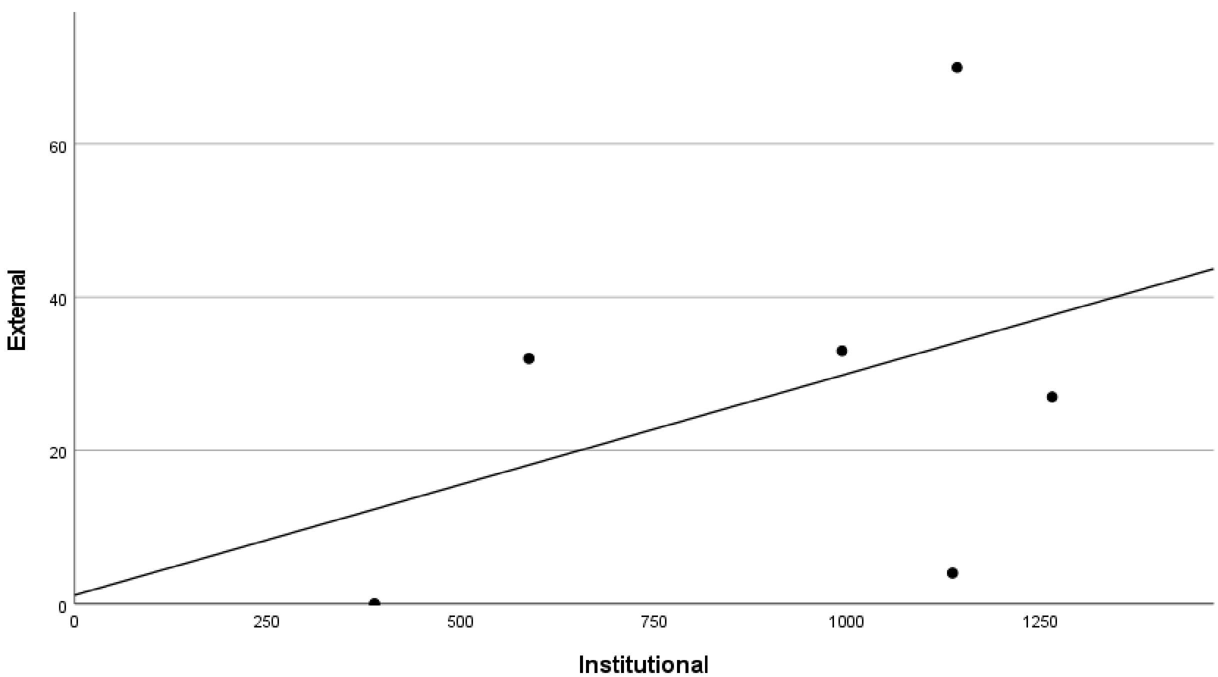


Figure 2.102

Normal Q-Q Plot of External for Psychology

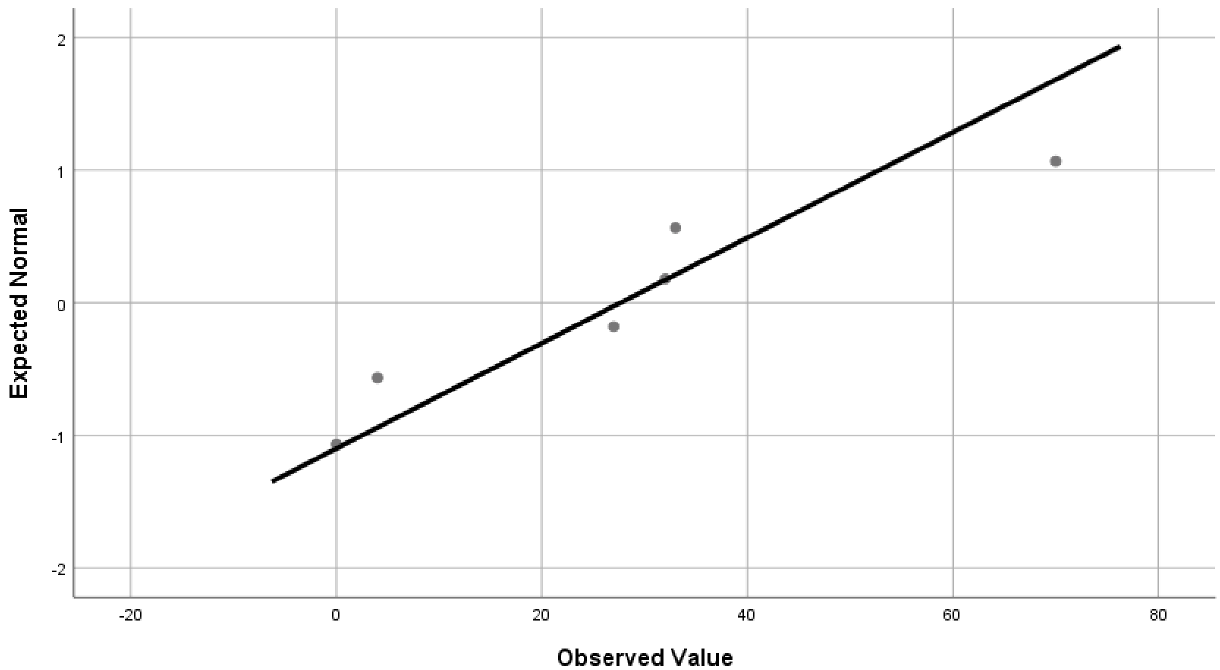


Figure 2.103

Normal P-P Plot of Regression Standardized Residual for Psychology

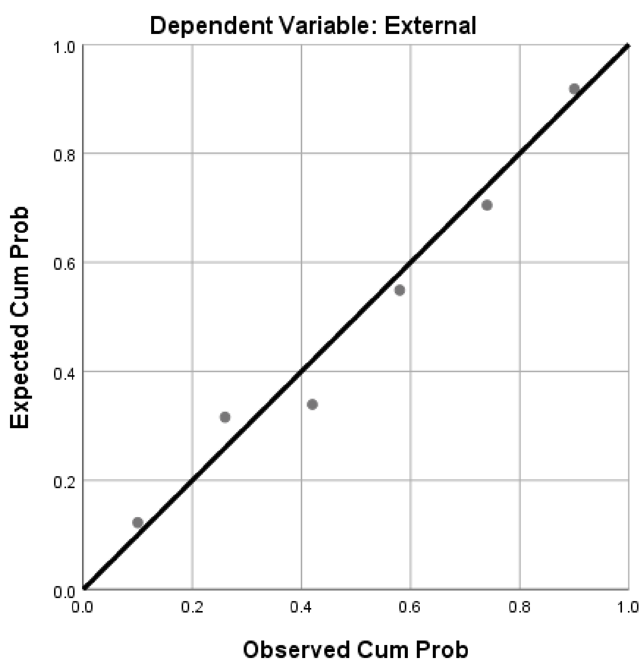
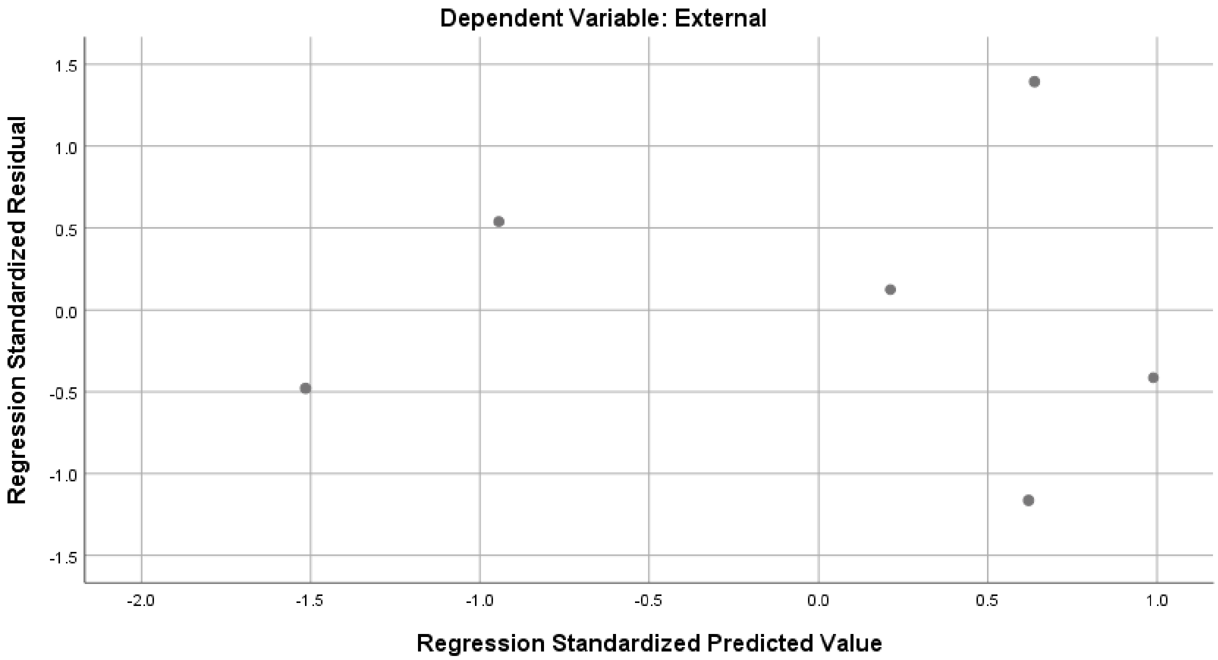


Figure 2.104

Scatterplot for Psychology



Social Sciences

Table 2.27 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Social Sciences R&D expenditures. Figure 2.105 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Social Sciences field reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.106 as half of the values fall closely along the line. Standardized residuals were somewhat normally distributed as shown in Figure 2.107 as more than half of the values fall closely along the line. Scatterplots in Figure 2.108 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Social Sciences field, $F(1,4) = .07$, $p = .800$. A small effect size was noted with approximately 1.8% of the variances accounted for in the model, $R^2 = .018$.

Table 2.27

Descriptive Statistics for Social Sciences (n = 6 and r = 0.13)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	320	977
2016	463	4536
2017	1317	4522
2018	772	4238
2019	399	5070
2020	922	1395
M	698.83	3456.33
SD	381.14	1783.95

Figure 2.105

Scatter Plot of External by Institutional for Social Sciences

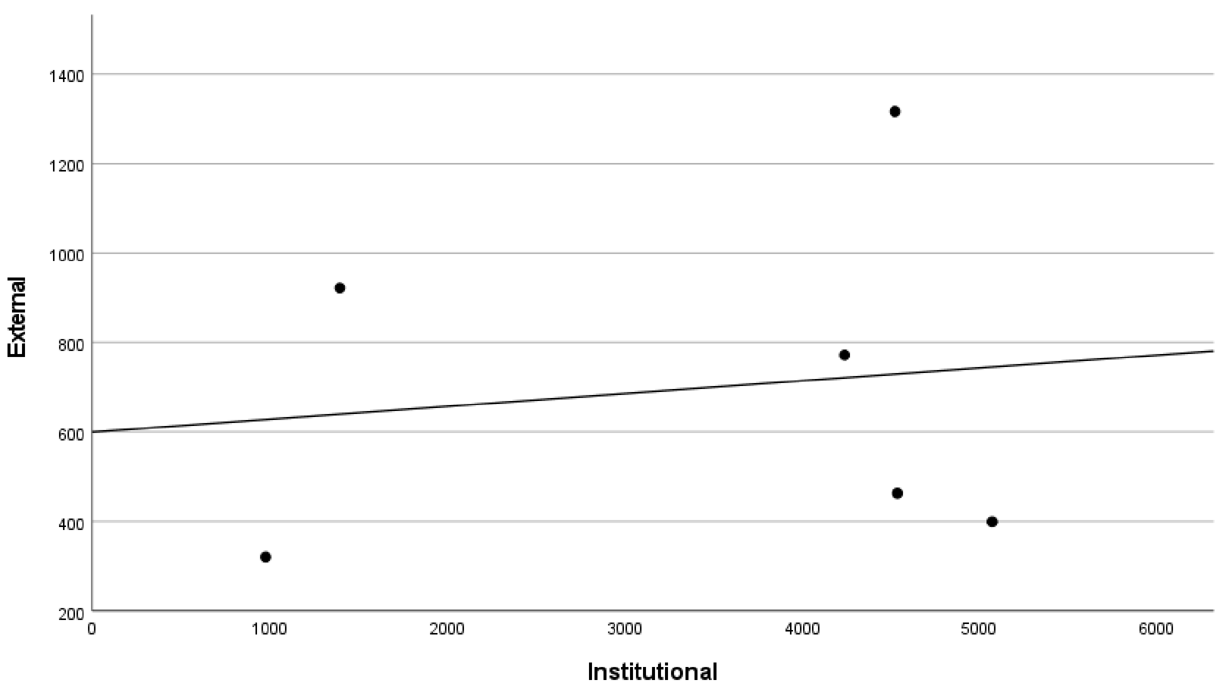


Figure 2.106

Normal Q-Q Plot of External for Social Sciences

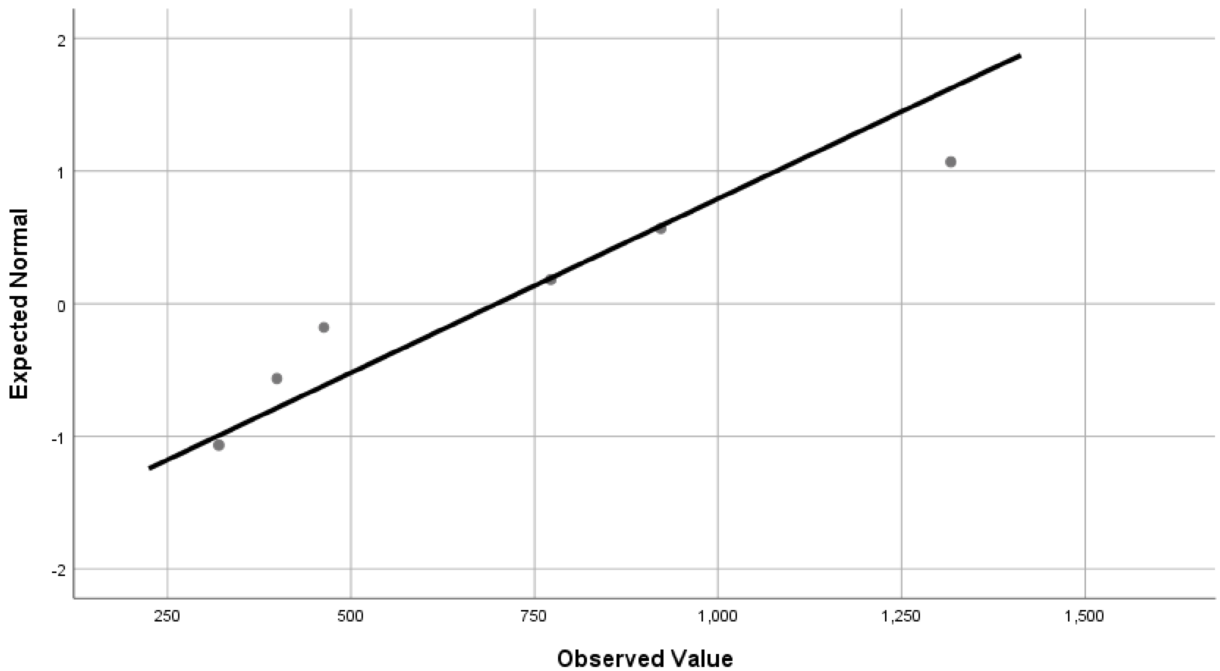


Figure 2.107

Normal P-P Plot of Regression Standardized Residual for Social Sciences

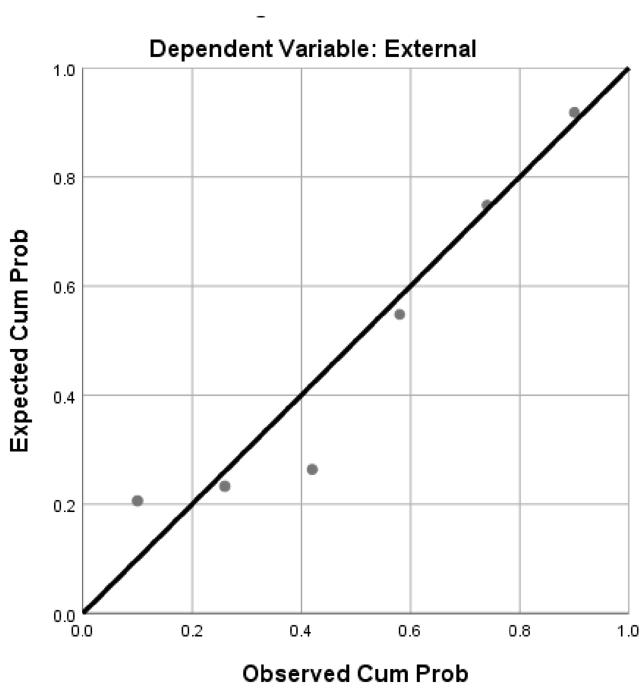
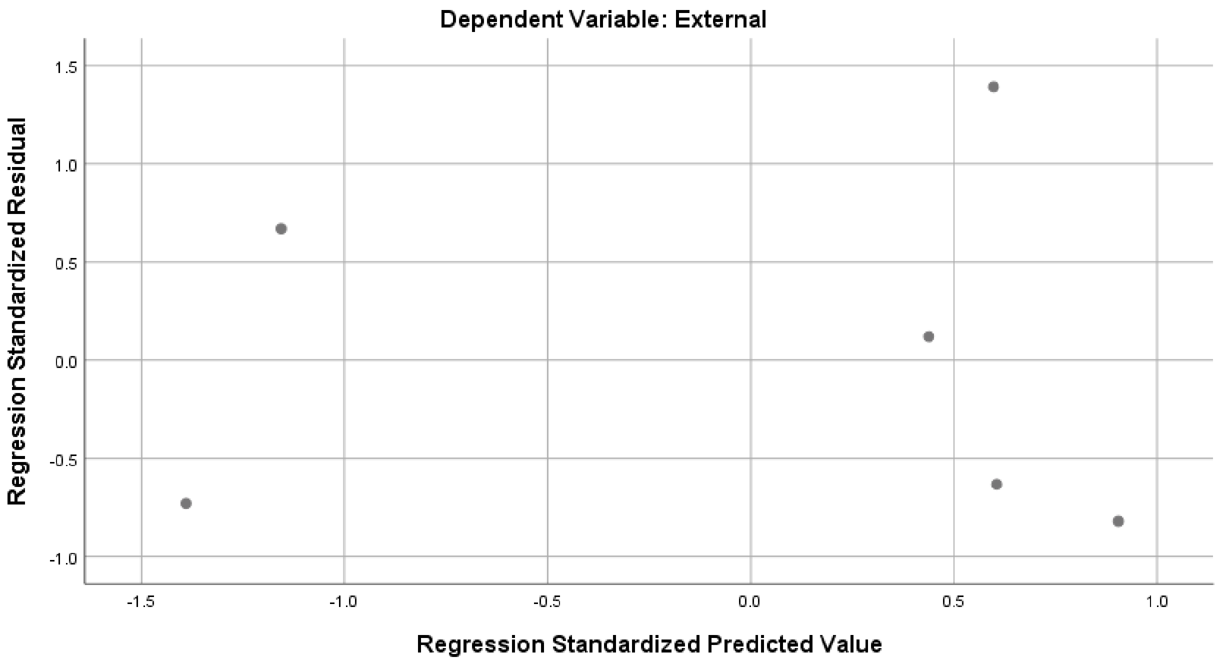


Figure 2.108

Scatterplot for Social Sciences



Political Science and Government

Table 2.28 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Political Science and Government R&D expenditures. Figure 2.109 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Political Science and Government subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.110. Standardized residuals were not normally distributed as shown in Figure 2.111. Scatterplots in Figure 2.112 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Political Science and Government subfield, $F(1,4) = .24$, $p = .652$.

A small effect size was noted with approximately 5.6% of the variances accounted for in the model, $R^2 = .056$.

Table 2.28

Descriptive Statistics for Political Science and Government (n = 6 and r = 0.24)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	4	363
2016	25	1166
2017	72	1146
2018	89	898
2019	33	1119
2020	56	316
M	46.50	834.67
SD	31.62	395.74

Figure 2.109

Scatter Plot of External by Institutional for Political Science and Government

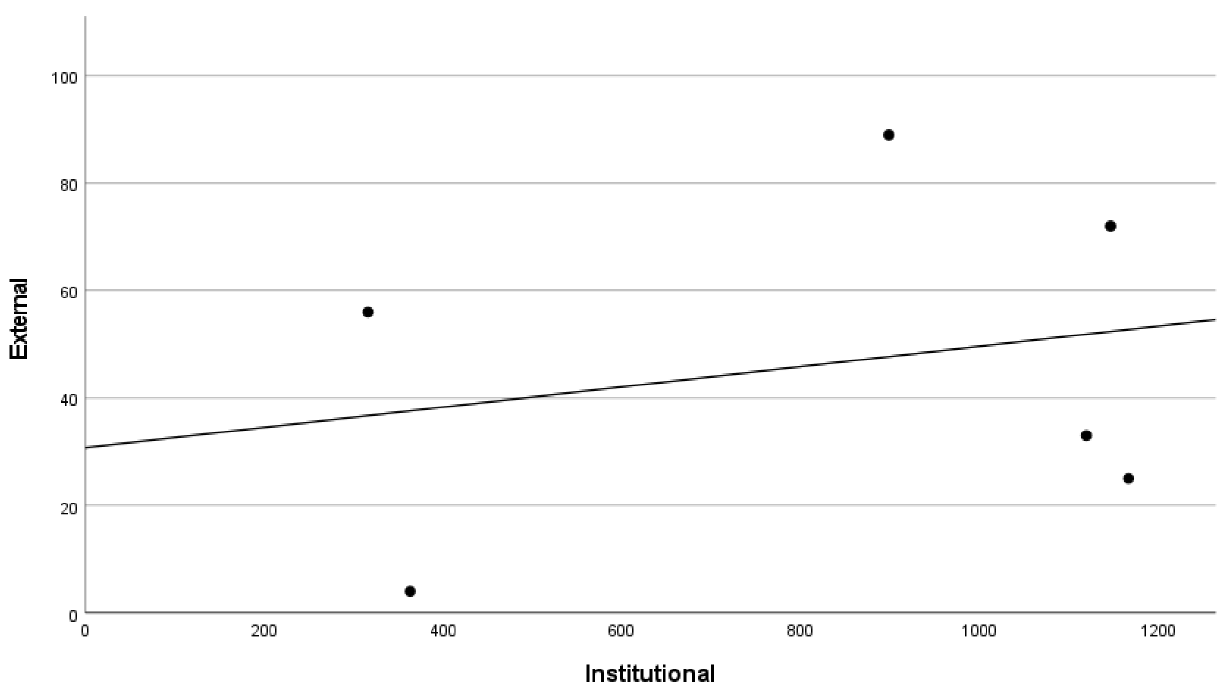


Figure 2.110

Normal Q-Q Plot of External for Political Science and Government

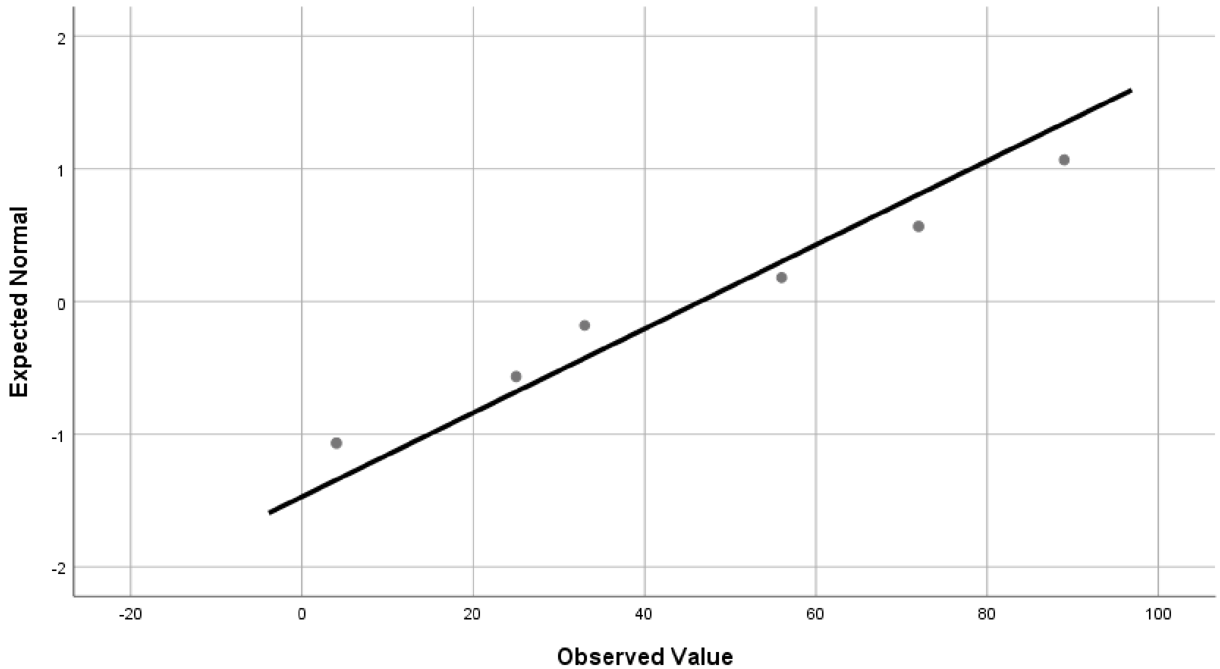


Figure 2.111

Normal P-P Plot of Regression Standardized Residual for Political Science and Government

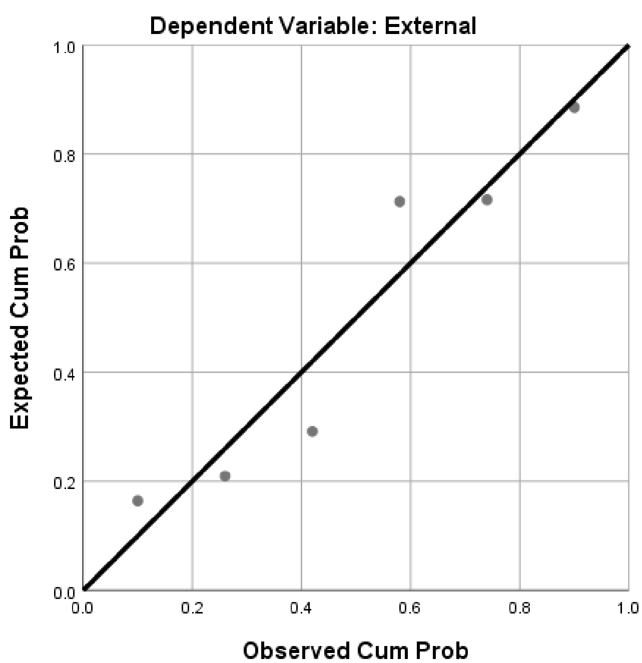
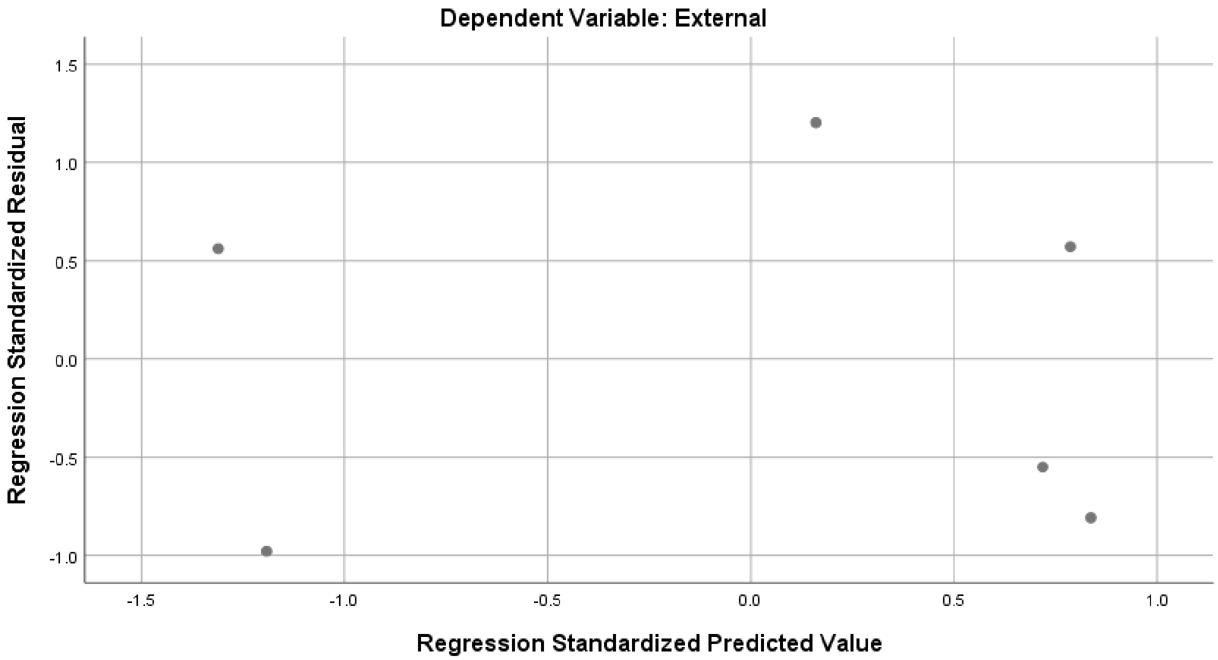


Figure 2.112

Scatterplot for Political Science and Government



Sociology, Demography, and Population Studies

Table 2.29 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Sociology, Demography, and Population (SD&P) Studies R&D expenditures. Figure 2.113 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Sociology, Demography, and Population Studies subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.114. Standardized residuals were not normally distributed as shown in Figure 2.115. Scatterplots in Figure 2.116 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Social, Demography, and Population Studies subfield, $F(1,4) = .09$, $p = .780$. A small effect size was noted with approximately 2.2% of the variances accounted for in the model, $R^2 = .022$.

Table 2.29

Descriptive Statistics for SD&P Studies (n = 6 and r = -0.15)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	248	552
2016	416	1160
2017	342	1386
2018	554	1272
2019	348	1481
2020	684	669
M	432.00	1086.67
SD	159.79	386.04

Figure 2.113

Scatter Plot of External by Institutional for SD&P Studies

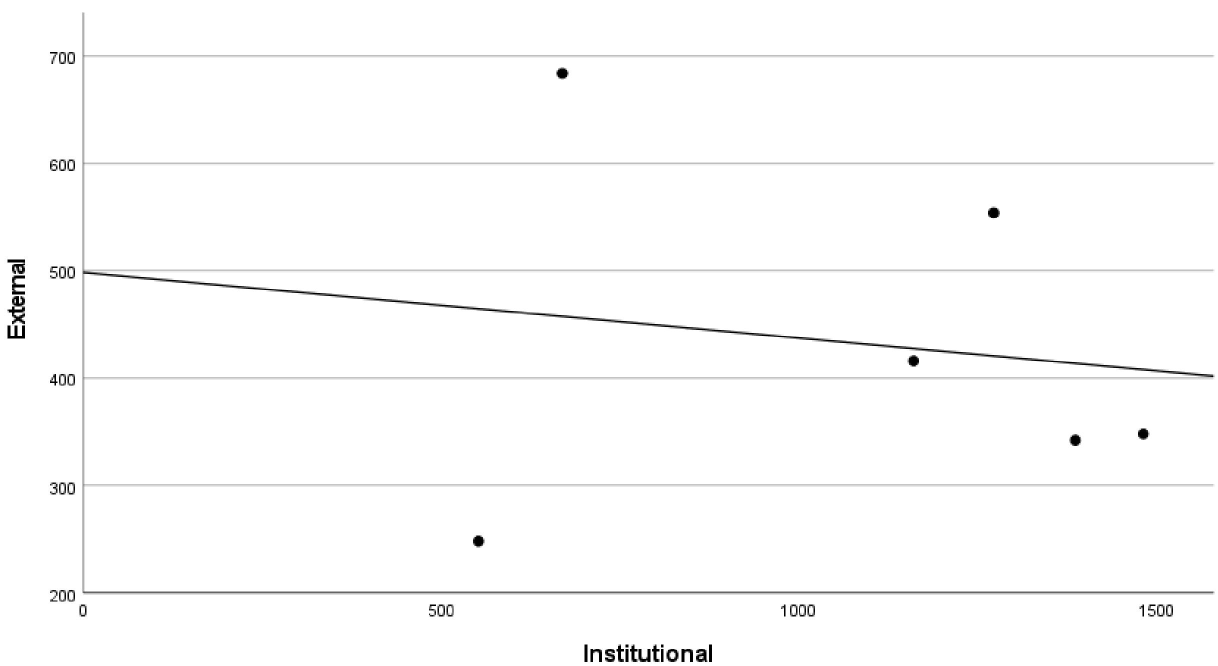


Figure 2.114

Normal Q-Q Plot of External for SD&P Studies

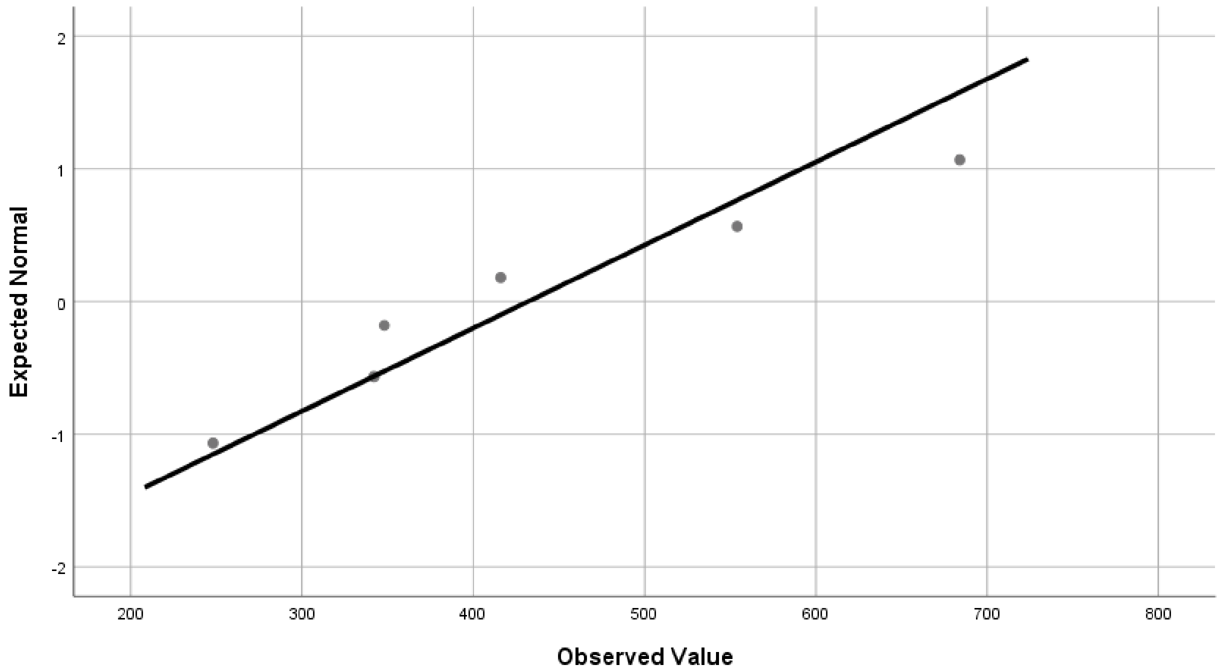


Figure 2.115

Normal P-P Plot of Regression Standardized Residual for SD&P Studies

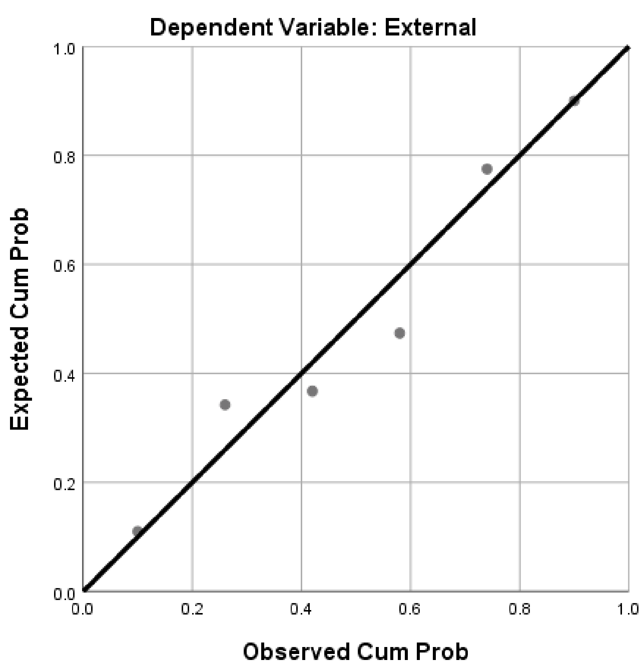
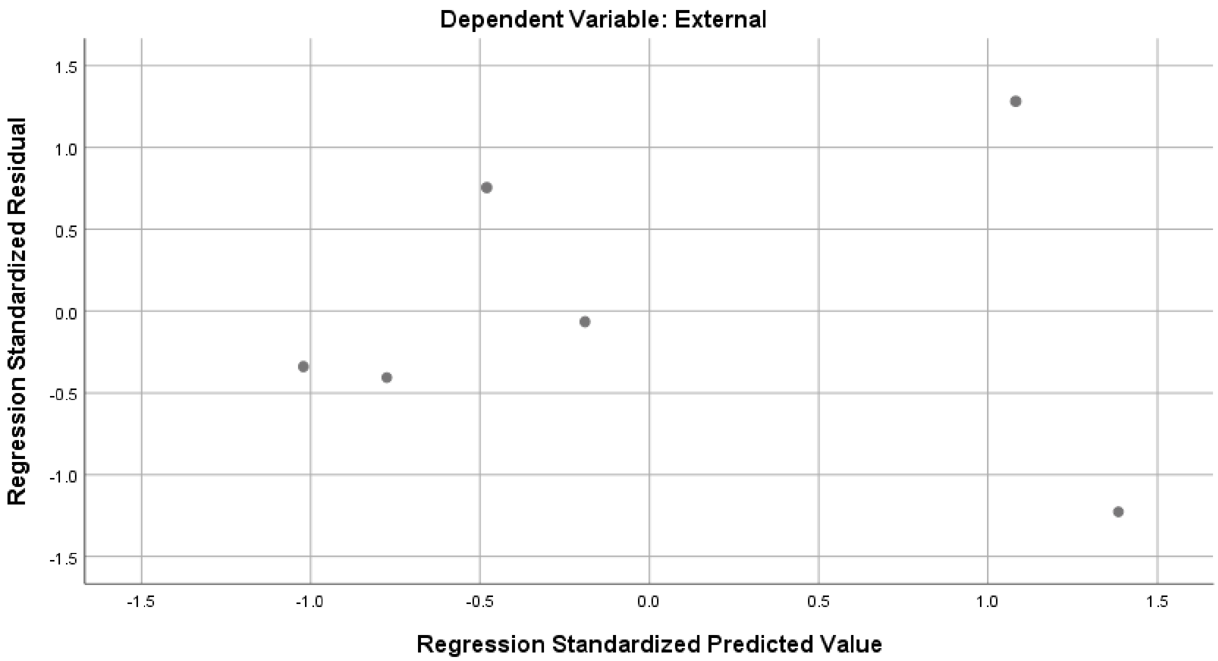


Figure 2.116

Scatterplot for SD&P Studies



Other Social Sciences

The NSF HERD Survey (n.d.) categorizes any Social Sciences fields that cannot be specifically identified within the previously listed subfields as Other Social Sciences. Table 2.30 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Social Sciences R&D expenditures. Figure 2.117 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Social Sciences subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.118. Standardized residuals were not normally distributed as shown in Figure 2.119. Scatterplots in Figure 2.120 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other

Social Sciences subfield, $F(1,4) = .81$, $p = .418$. A medium effect size was noted with approximately 16.9% of the variances accounted for in the model, $R^2 = .169$.

Table 2.30

Descriptive Statistics for Other Social Sciences (n = 6 and r = -0.41)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2015	68	30
2016	7	257
2017	56	16
2018	129	250
2019	18	387
2020	155	65
M	72.17	167.50
SD	59.25	151.90

Figure 2.117

Scatter Plot of External by Institutional for Other Social Sciences

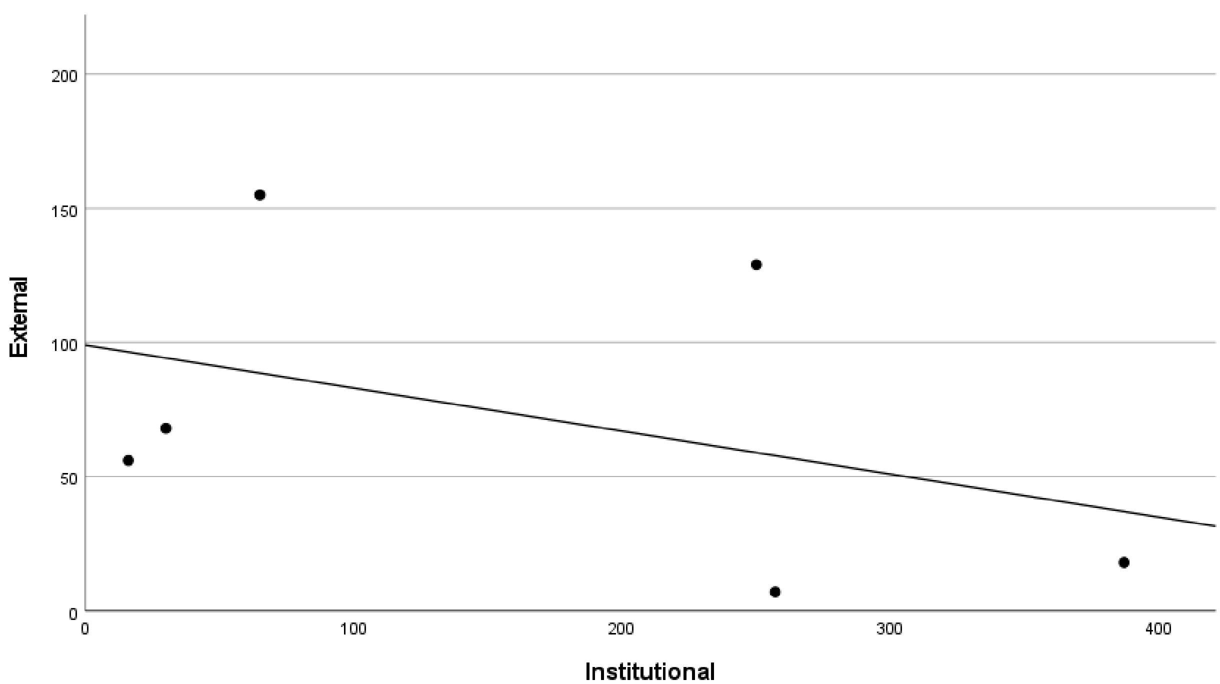


Figure 2.118

Normal Q-Q Plot of External for Other Social Sciences

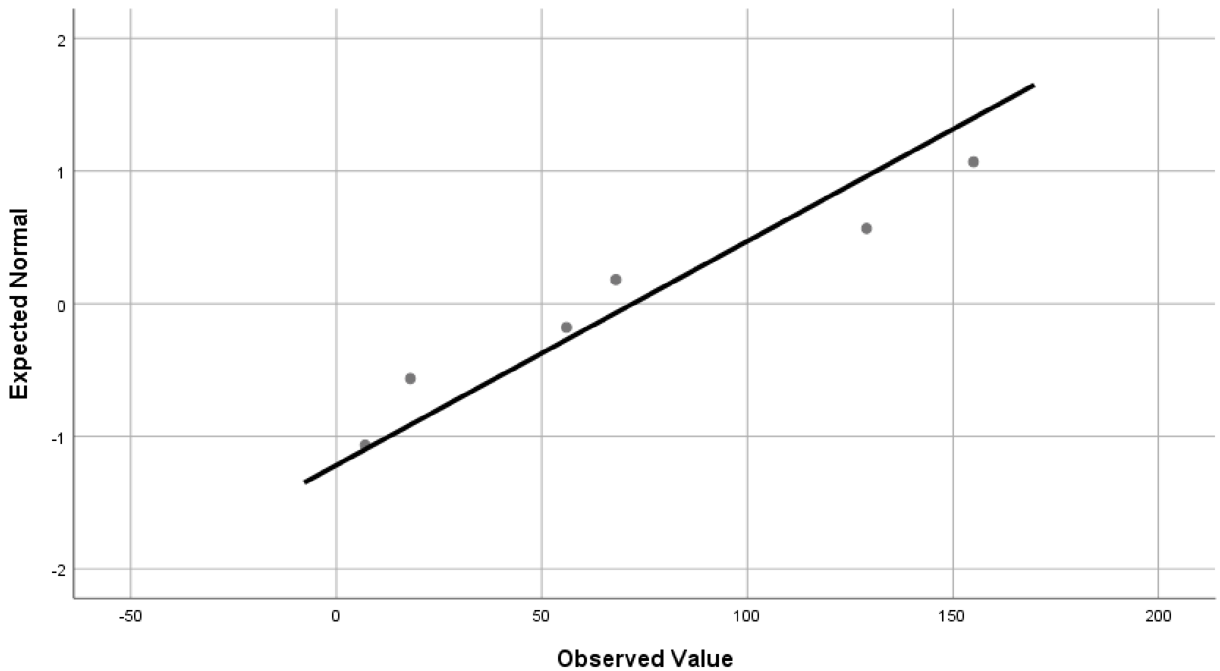


Figure 2.119

Normal P-P Plot of Regression Standardized Residual for Other Social Sciences

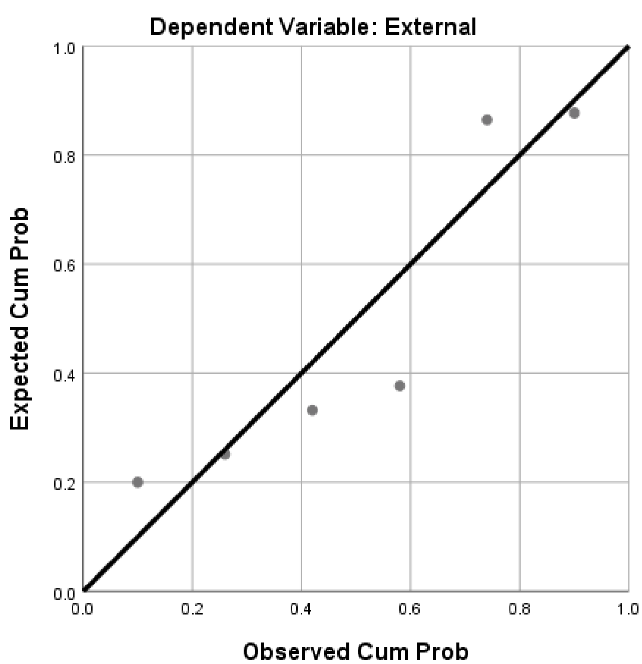
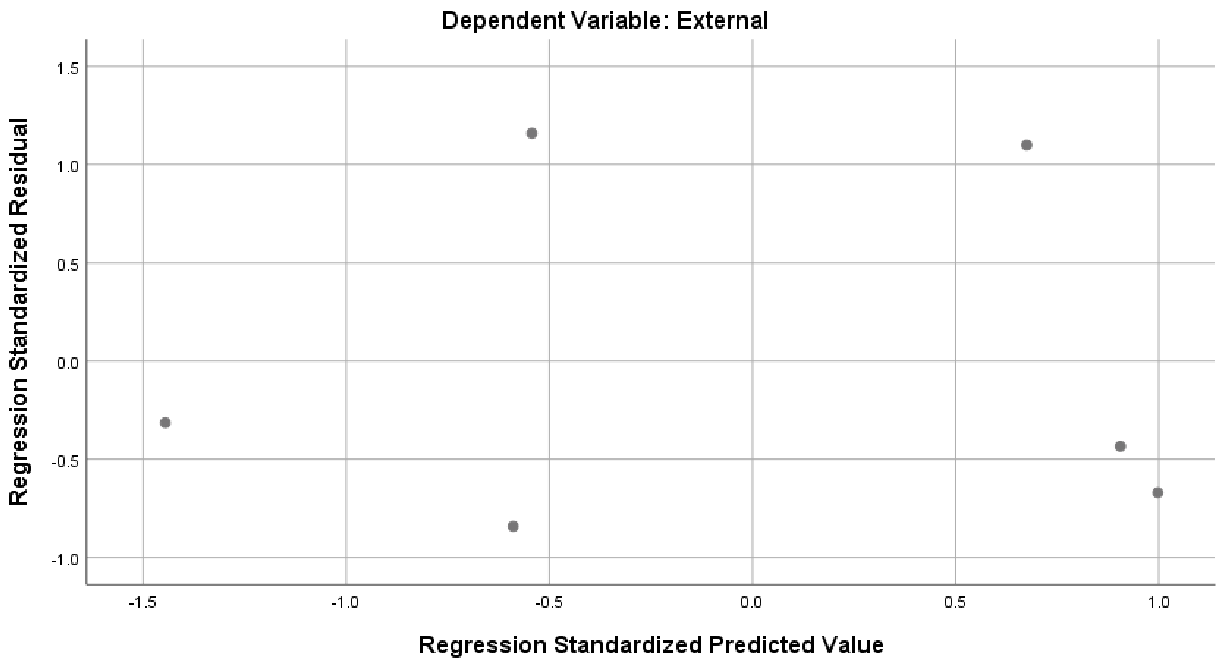


Figure 2.120

Scatterplot for Other Social Sciences



Initial Data Analyses Trends

The preceding sections present the results of simple linear regressions of institutionally and externally funded R&D expenditures across 30 fields and subfields from the NSF HERD Survey from 2015 through 2020, as summarized in Appendix A. Directionally, the regressions were approximately split in half with 14 fields and subfields, or 47%, reflecting a positive correlation between the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures. The positive correlation indicates externally funded R&D expenditures increased as institutionally funded R&D expenditures increased. There was a negative correlation in 16 fields and subfields, or 53%, with externally funded R&D expenditures decreasing as institutionally funded R&D expenditures increased. The regressions did not identify any relationships between institutionally and externally funded R&D expenditures in any field or subfield.

The absence of relationships and existence of many negative correlations were unexpected and caused me to consider how I might approach further analysis of the survey data.

Secondary Data Analyses

I shared the preliminary results from the initial data analyses with a colleague with higher education financial administration expertise. We discussed that the potential benefit of institutionally funded R&D might not be realized until the following fiscal year. To identify the existence of relationships based on a one fiscal year delay in the return on investment from institutionally funded R&D, I conducted additional data analyses with simple linear regressions of the predictor (independent) variable of institutionally funded R&D expenditures from 2014 through 2019 and the criterion (dependent) variable of externally funded R&D expenditures for the following fiscal years of 2015 through 2020. An alpha level of .05 was utilized. Descriptive statistics of externally and institutionally funded R&D expenditures shown as thousands of dollars, the mean (*M*) and standard deviation (*SD*) are reported in tables with scatterplots and standardized residuals reflected in figures for each field and subfield as categorized in the NSF HERD survey. Fields and subfields with less than six fiscal years of data are excluded from analysis.

Computer and Information Sciences

Table 2.31 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Computer and Information Sciences R&D expenditures. Figure 2.121 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Computer and Information Sciences field reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.122. Standardized residuals were not normally distributed as shown in Figure 2.123. Scatterplots in Figure 2.124 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the field of Computer and Information Sciences, $F(1,4) = 0.23$, $p = .655$. A small effect size was noted with only 5.5% of the variances accounted for in the model, $R^2 = .055$.

Table 2.31

Descriptive Statistics for Computer and Information Sciences (n = 6 and r = -0.23)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	108
2015	163	85
2016	88	516
2017	103	96
2018	53	551
2019	46	538
2020	101	-
M	92.33	315.67
SD	42.18	240.64

Figure 2.121

Scatter Plot of External by Institutional for Computer and Information Sciences

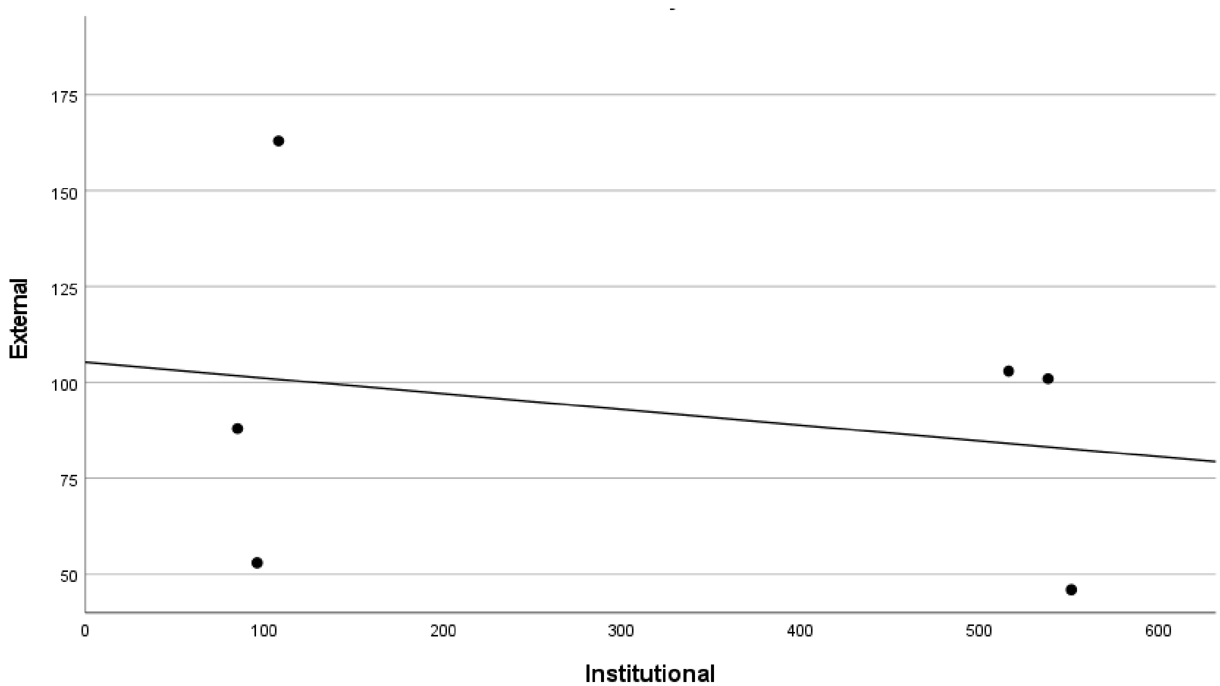


Figure 2.122

Normal Q-Q Plot of External for Computer and Information Sciences

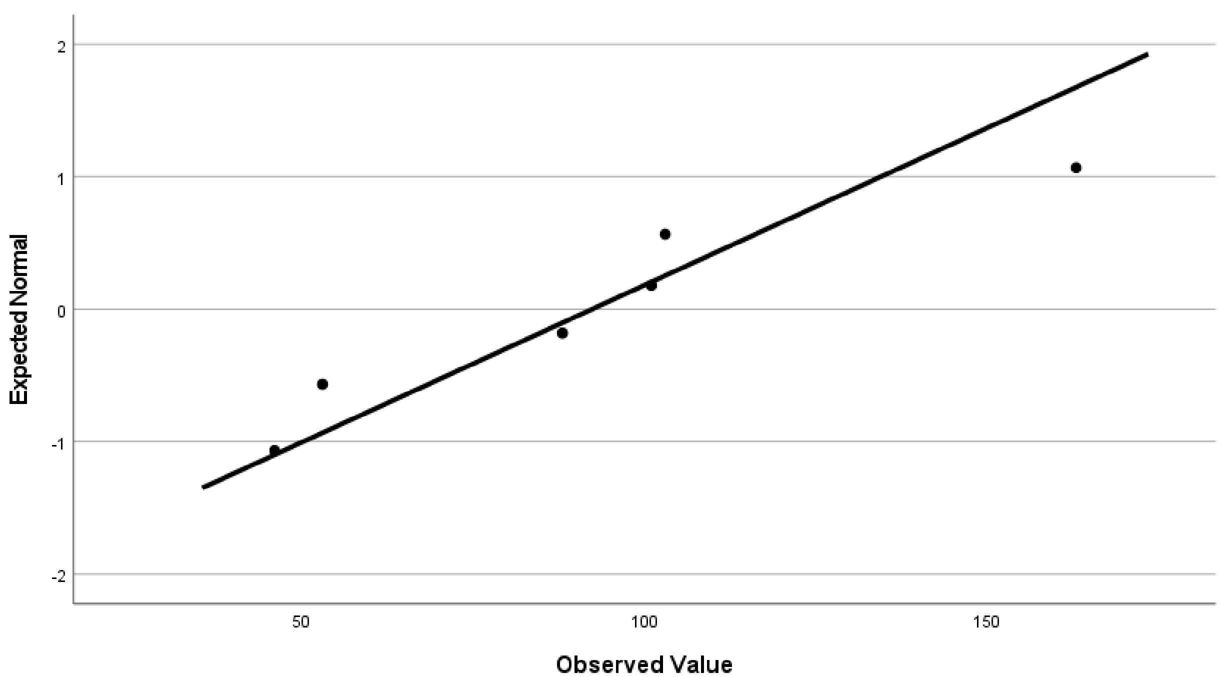


Figure 2.123

Normal P-P Plot of Regression Standardized Residual for Computer and Information Sciences

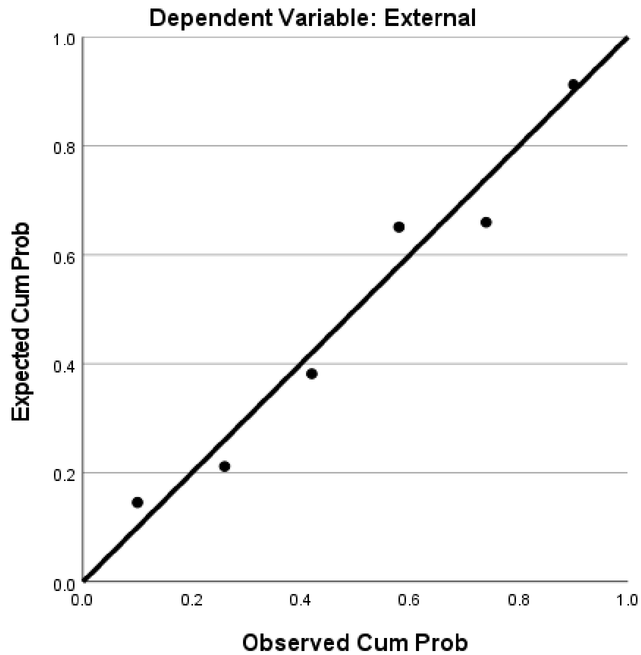
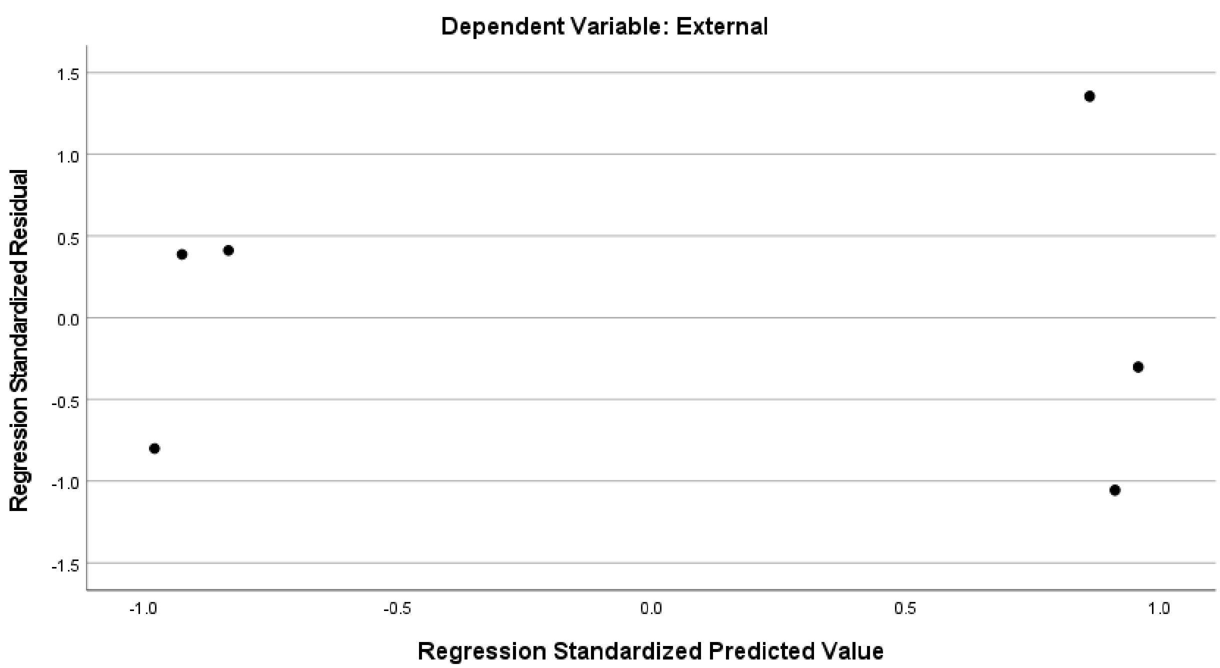


Figure 2.124

Scatterplot for Computer and Information Sciences



Engineering

Table 2.32 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Engineering R&D expenditures. Figure 2.125 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Engineering field reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.126. Standardized residuals were not normally distributed as shown in Figure 2.127. Scatterplots in Figure 2.128 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the field of Engineering, $F(1,4) = 0.52$, $p = .510$. A small effect size was noted with approximately 11.5% of the variances accounted for in the model, $R^2 = .115$.

Table 2.32

Descriptive Statistics for Engineering (n = 6 and r = 0.34)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	1726
2015	4055	1621
2016	3338	3308
2017	2740	4507
2018	3298	2164
2019	4864	3957
2020	12499	-
M	5132.33	2880.50
SD	3682.61	1218.17

Figure 2.125

Scatter Plot of External by Institutional for Engineering

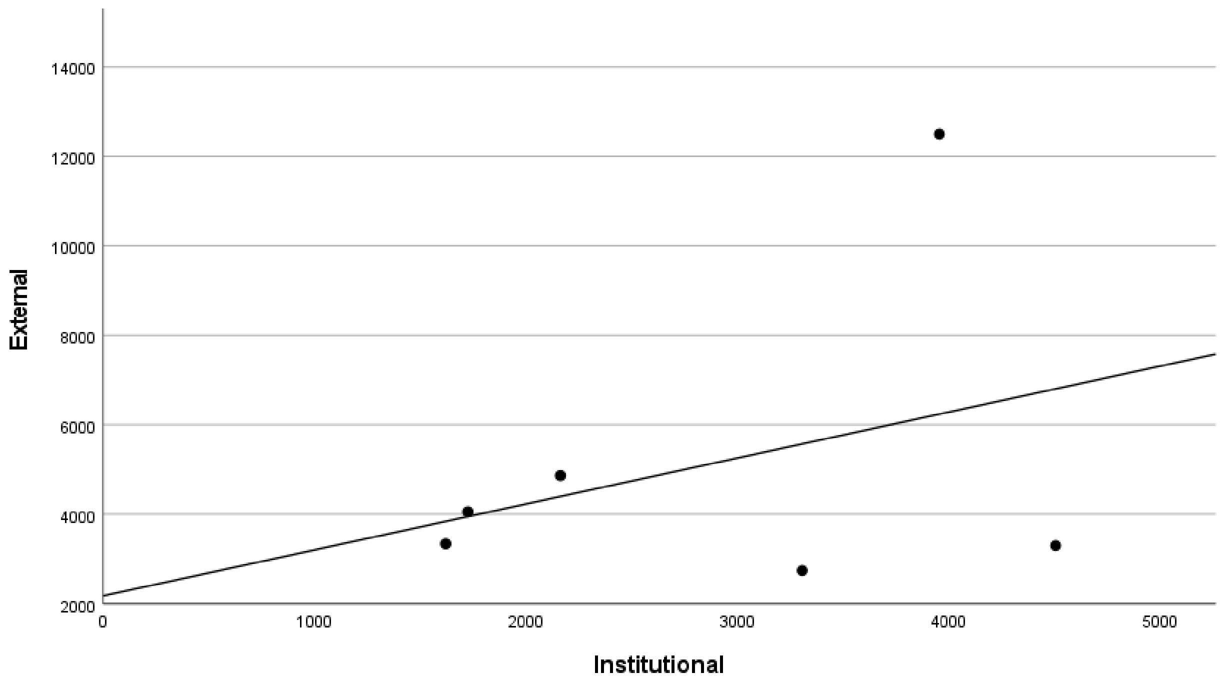


Figure 2.126

Normal Q-Q Plot of External for Engineering

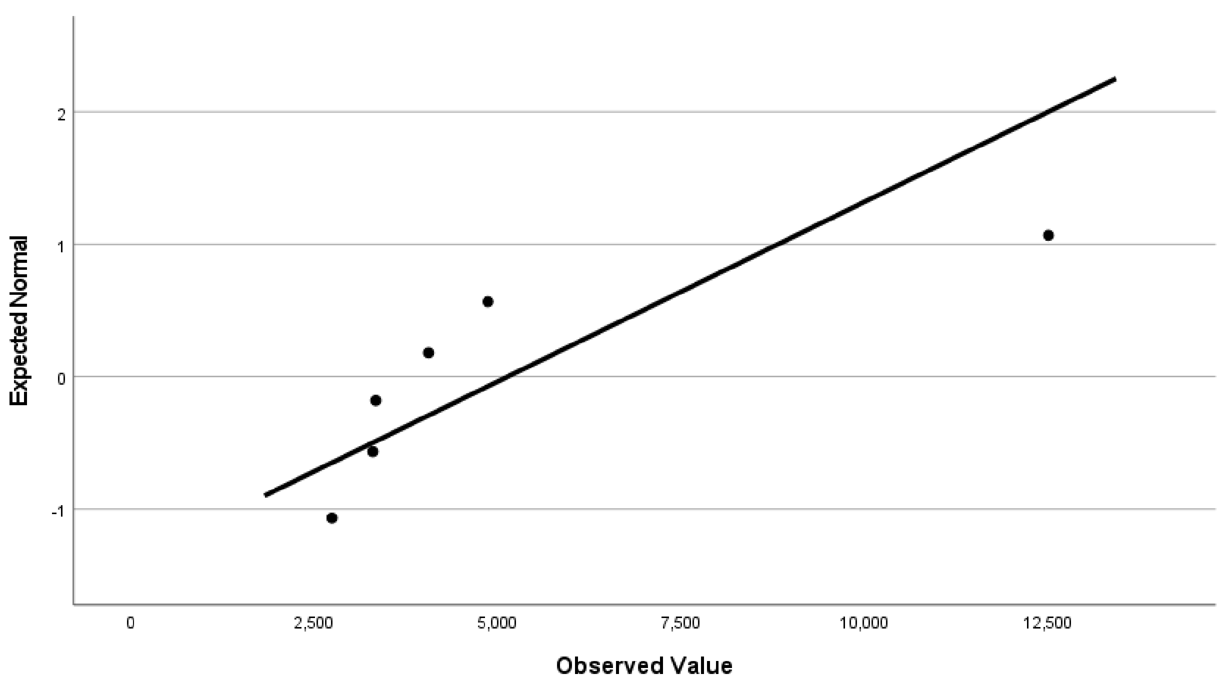


Figure 2.127

Normal P-P Plot of Regression Standardized Residual for Engineering

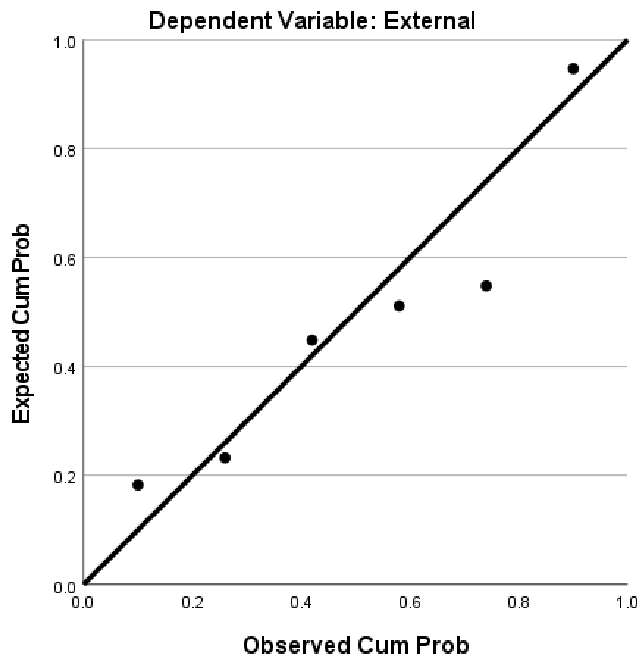
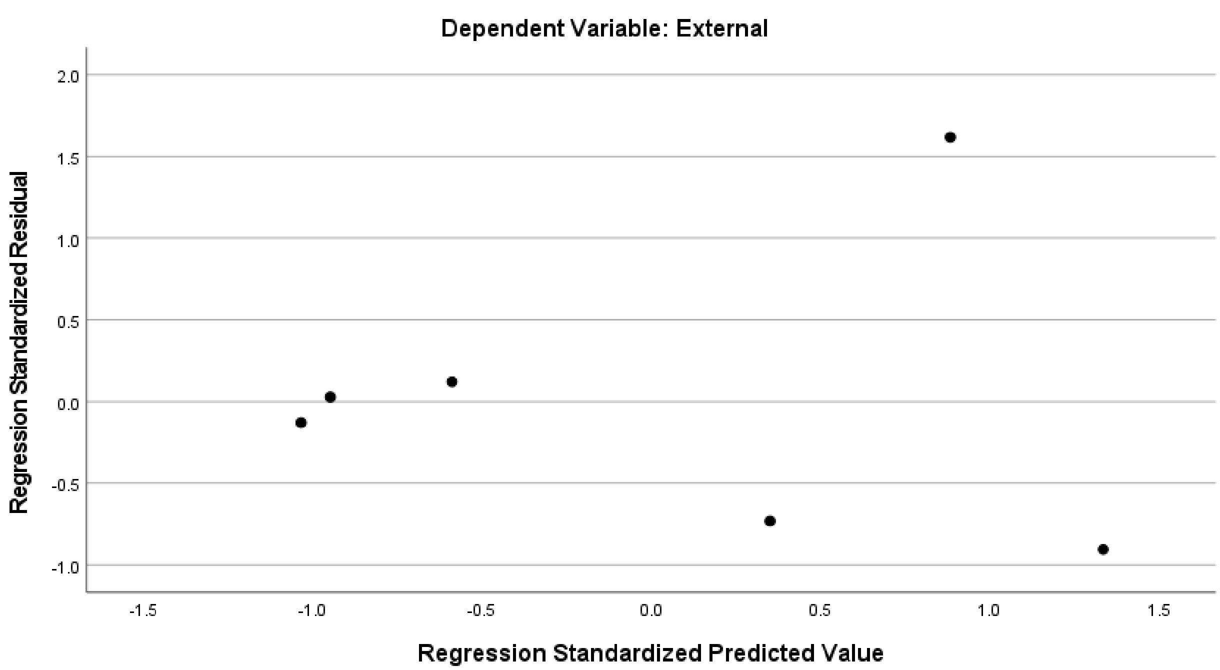


Figure 2.128

Scatterplot for Engineering



Chemical Engineering

Table 2.33 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Chemical Engineering R&D expenditures. Figure 2.129 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Chemical Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.130. Standardized residuals were not normally distributed as shown in Figure 2.131. Scatterplots in Figure 2.132 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Chemical Engineering subfield, $F(1,4) = .78$, $p = .426$. A medium effect size was noted with approximately 16.4% of the variances accounted for in the model, $R^2 = .164$.

Table 2.33

Descriptive Statistics for Chemical Engineering (n = 6 and r = -0.41)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	194
2015	1251	260
2016	1127	802
2017	990	1944
2018	1066	379
2019	1142	1114
2020	496	-
M	1012.00	782.17
SD	267.17	669.55

Figure 2.129

Scatter Plot of External by Institutional for Chemical Engineering

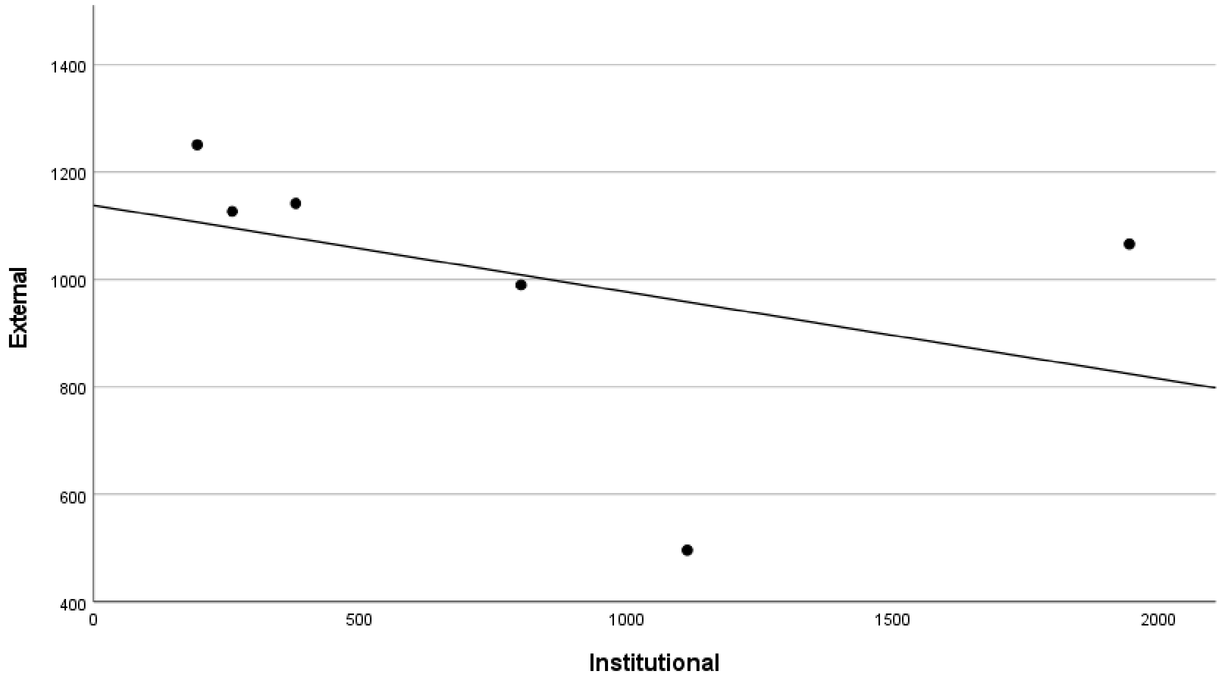


Figure 2.130

Normal Q-Q Plot of External for Chemical Engineering

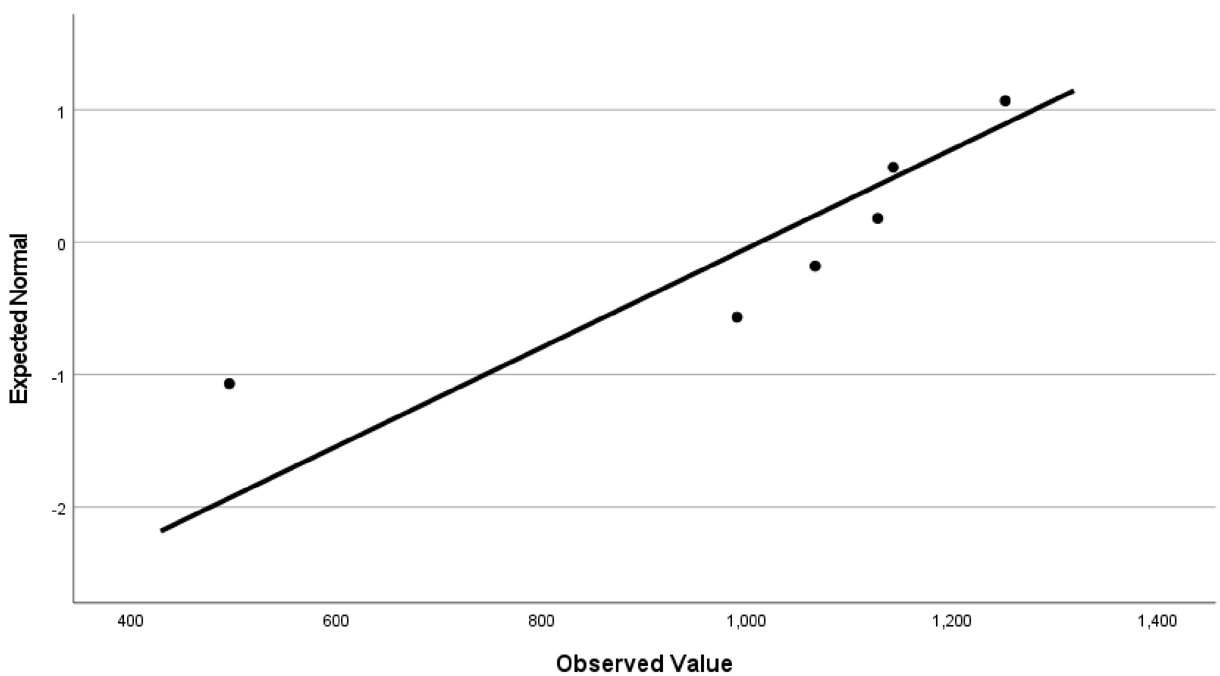


Figure 2.131

Normal P-P Plot of Regression Standardized Residual for Chemical Engineering

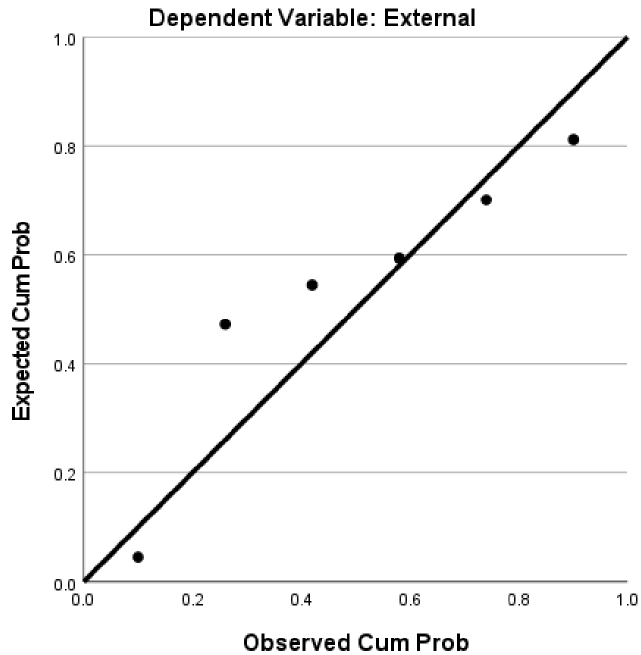
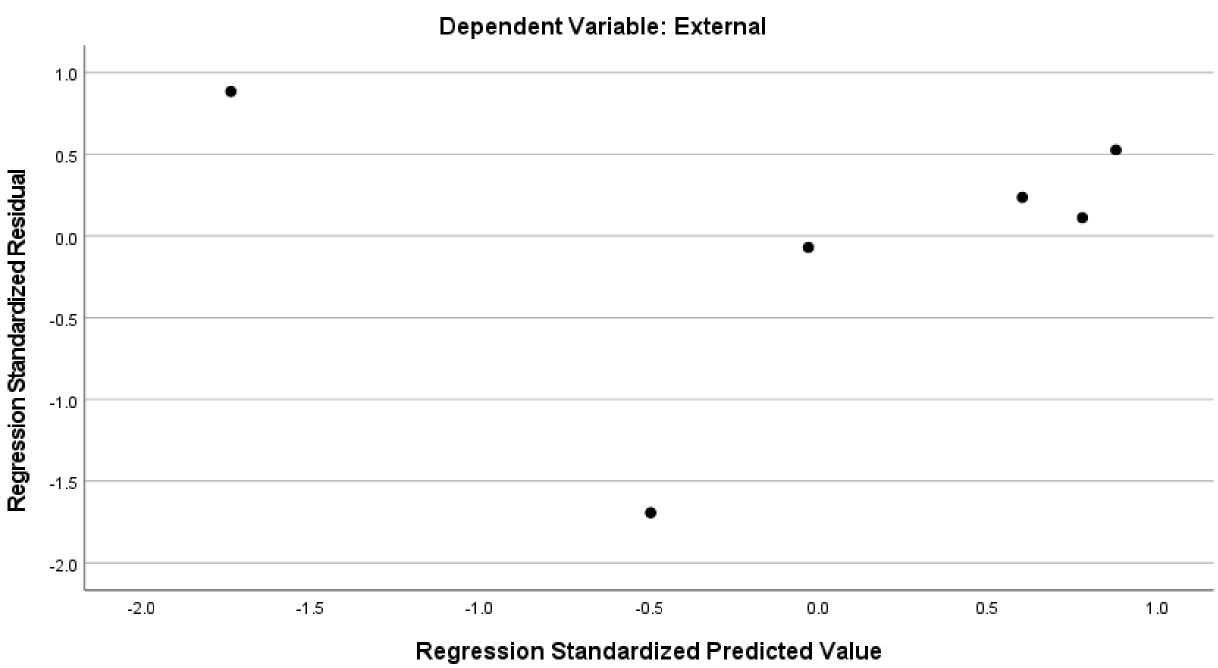


Figure 2.132

Scatterplot for Chemical Engineering



Civil Engineering

Table 2.34 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Chemical Engineering R&D expenditures. Figure 2.133 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Civil Engineering subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.134. Standardized residuals were not normally distributed as shown in Figure 2.135. Scatterplots in Figure 2.136 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Civil Engineering subfield, $F(1,4) = .79$, $p = .423$. A medium effect size was noted with approximately 16.6% of the variances accounted for in the model, $R^2 = .166$.

Table 2.34

Descriptive Statistics for Civil Engineering (n = 6 and r = 0.41)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	349
2015	373	59
2016	176	580
2017	78	427
2018	112	73
2019	345	944
2020	573	-
M	276.17	405.33
SD	188.93	333.08

Figure 2.133

Scatter Plot of External by Institutional for Civil Engineering

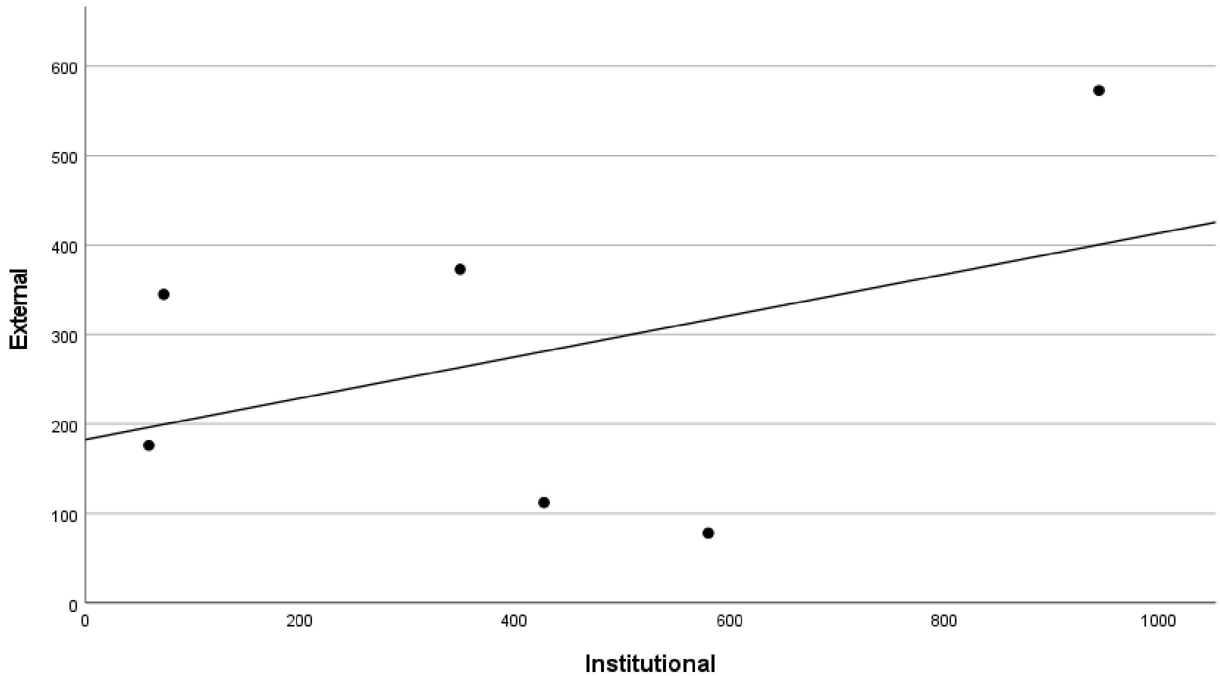


Figure 2.134

Normal Q-Q Plot of External for Civil Engineering

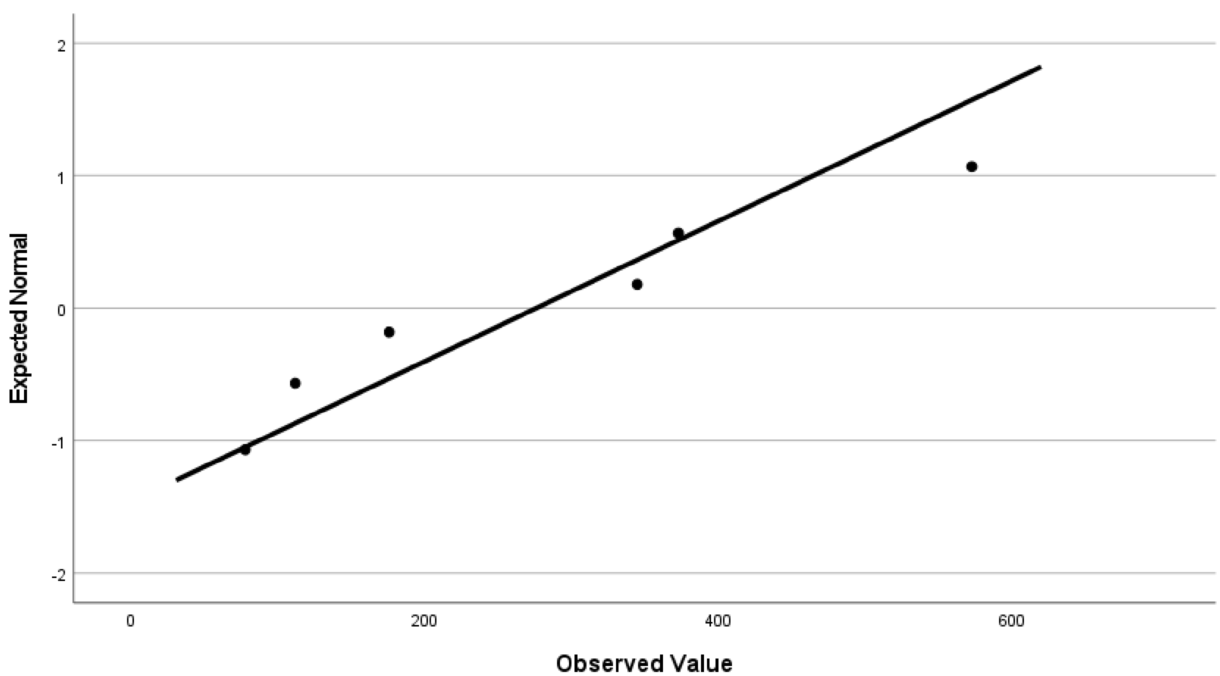


Figure 2.135

Normal P-P Plot of Regression Standardized Residual for Civil Engineering

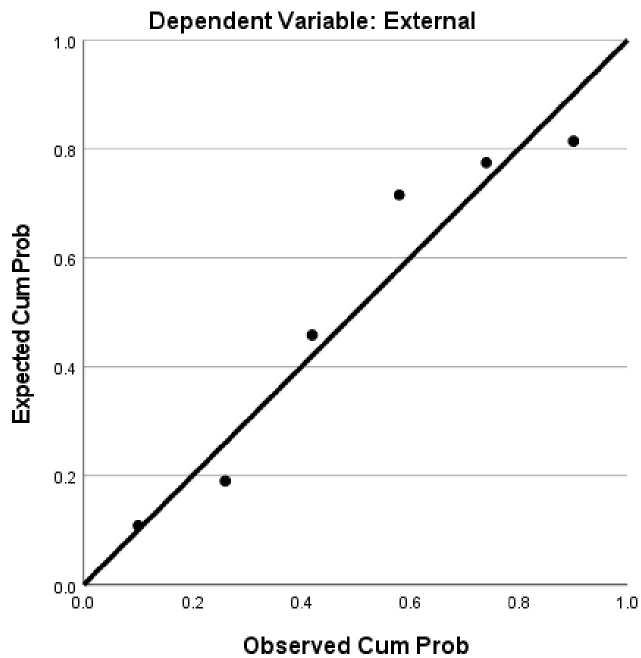
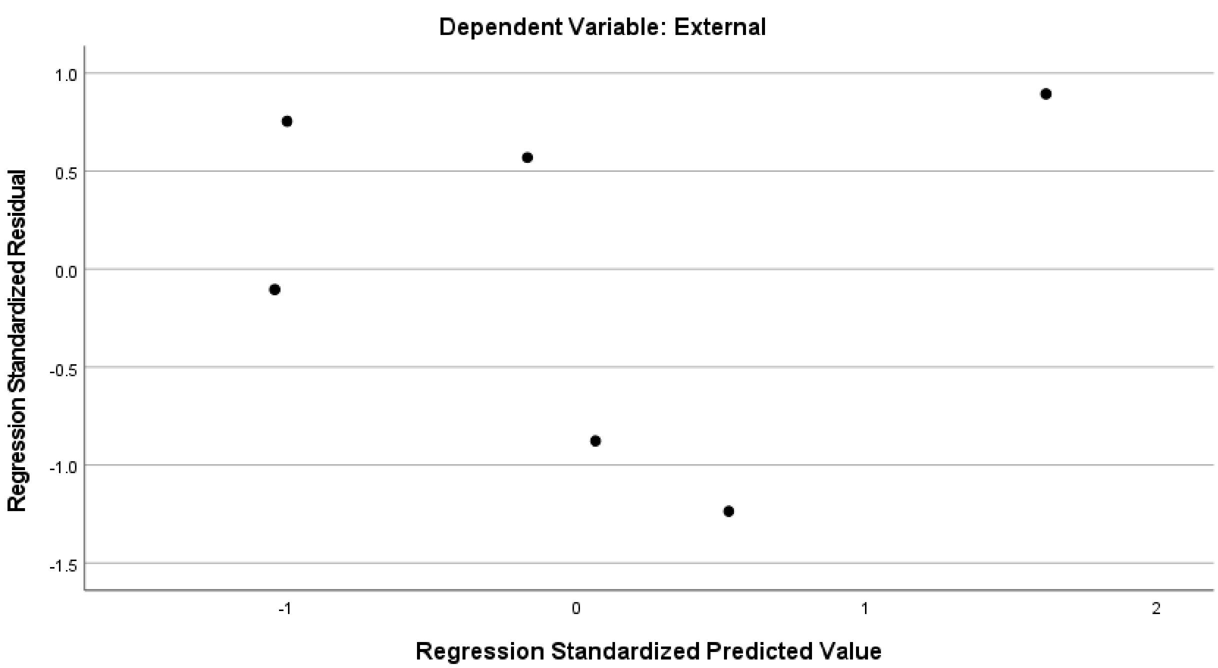


Figure 2.136

Scatterplot for Civil Engineering



Electrical, Electronic, and Communications Engineering

Table 2.35 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Electrical, Electronic, and Communications (EE&C) Engineering R&D expenditures. Figure 2.137 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Electrical, Electronic, and Communications Engineering subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.138. Standardized residuals were not normally distributed as shown in Figure 2.139. Scatterplots in Figure 2.140 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Electrical, Electronic, and Communications Engineering subfield, $F(1,4) = 2.86$, $p = .166$. A large effect size was noted with approximately 41.7% of the variances accounted for in the model, $R^2 = .417$.

Table 2.35

Descriptive Statistics for EE&C Engineering (n = 6 and r = 0.65)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	89
2015	9	71
2016	70	743
2017	223	724
2018	325	633
2019	354	840
2020	1479	-
M	410.00	516.67
SD	541.20	344.62

Figure 2.137

Scatter Plot of External by Institutional for EE&C Engineering

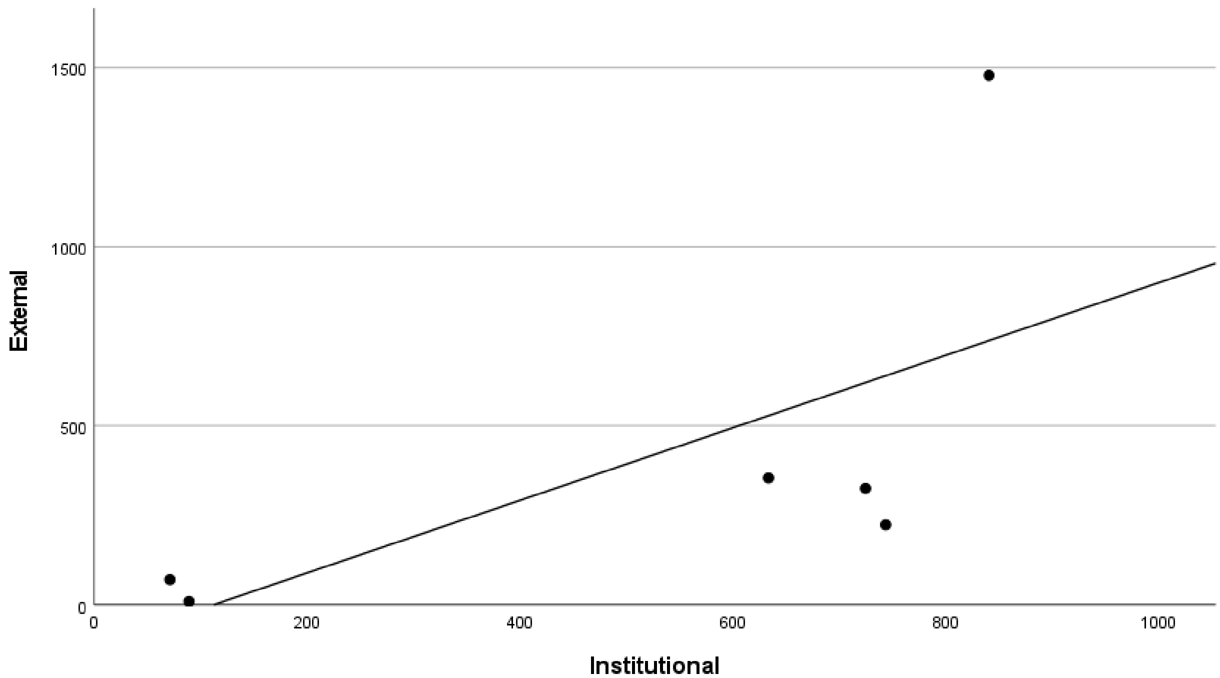


Figure 2.138

Normal Q-Q Plot of External for EE&C Engineering

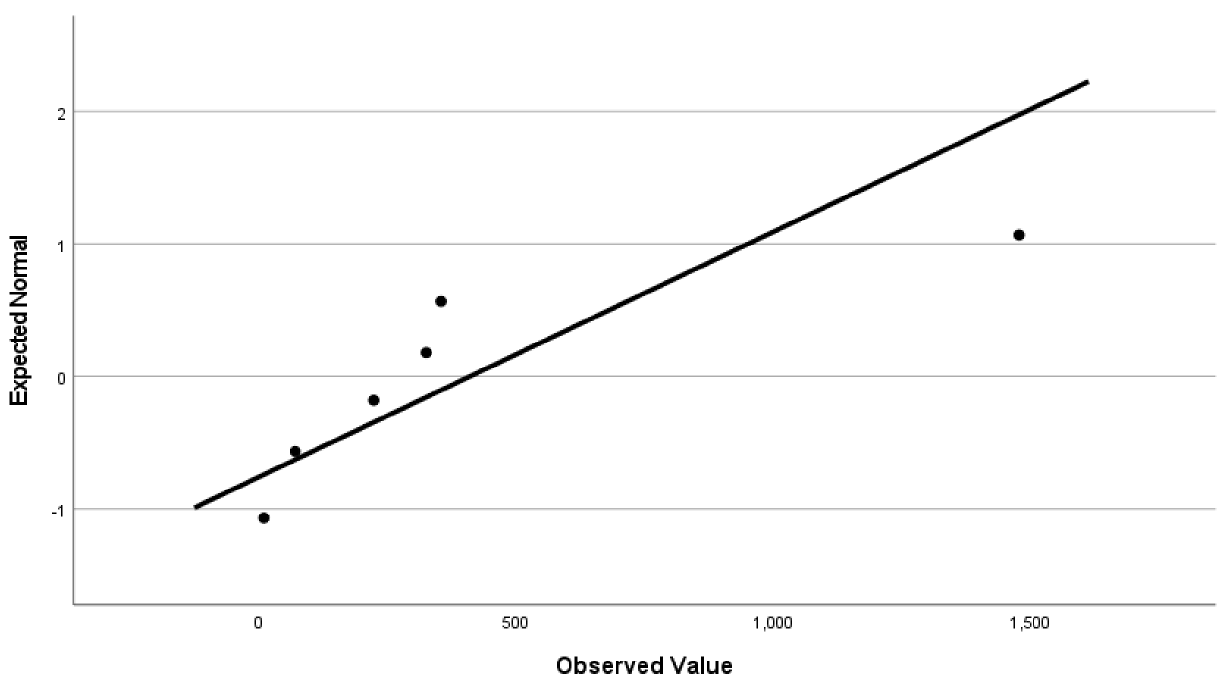


Figure 2.139

Normal P-P Plot of Regression Standardized Residual for EE&C Engineering

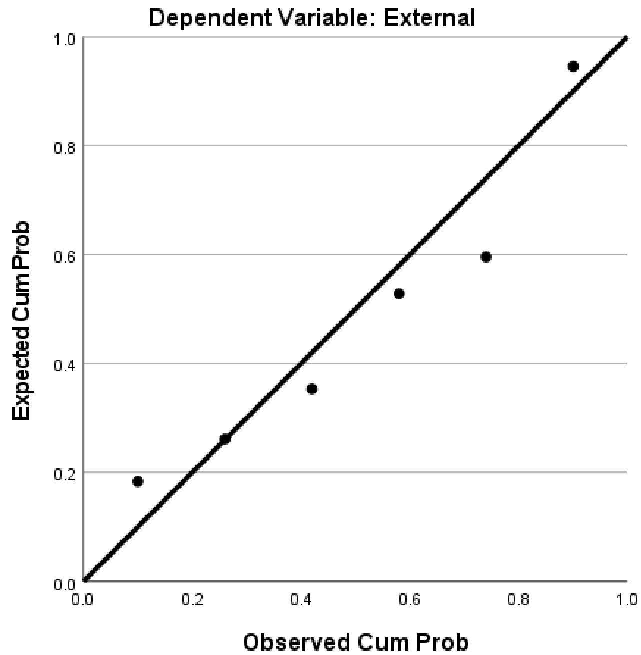
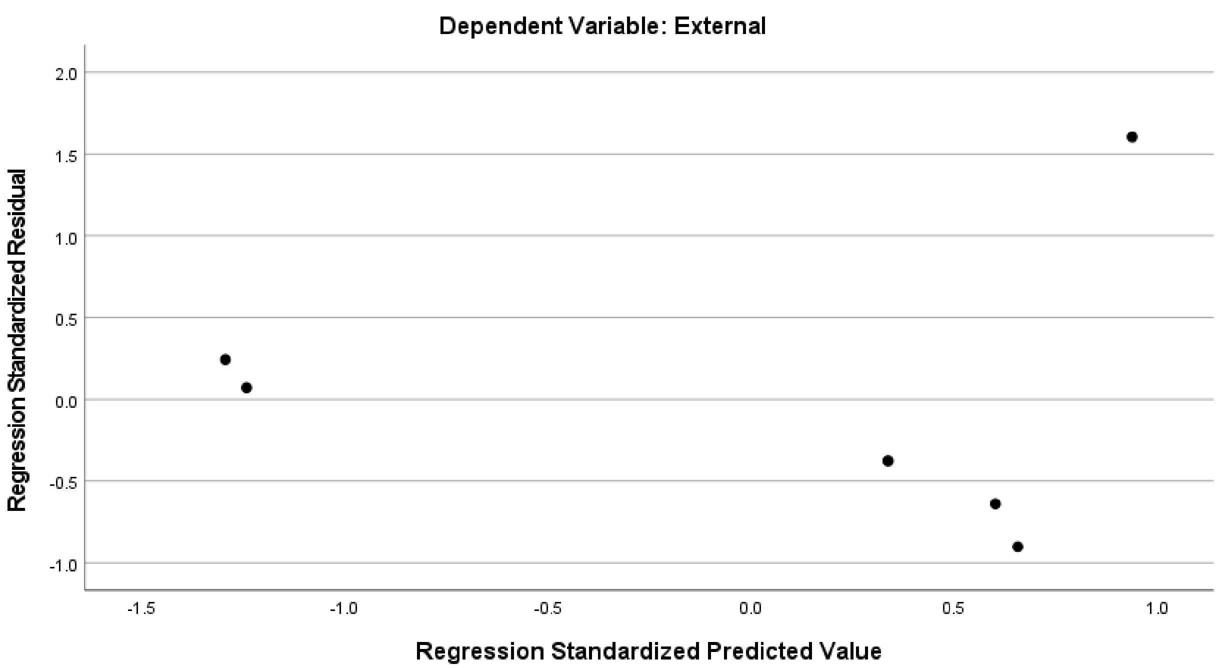


Figure 2.140

Scatterplot for EE&C Engineering



Mechanical Engineering

Table 2.36 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Mechanical Engineering R&D expenditures. Figure 2.141 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Mechanical Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.142, and standardized residuals were somewhat normally distributed as shown in Figure 2.143 as half of the values fell closely on the line. Scatterplots in Figure 2.144 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Mechanical Engineering subfield, $F(1,4) = .01$, $p = .938$. A small effect size was noted with approximately 0.20% of the variances accounted for in the model, $R^2 = 0.002$.

Table 2.36

Descriptive Statistics for Mechanical Engineering (n = 6 and r = -0.04)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	149
2015	606	509
2016	340	715
2017	394	673
2018	155	595
2019	458	818
2020	800	-
M	458.83	576.50
SD	223.02	234.30

Figure 2.141

Scatter Plot of External by Institutional for Mechanical Engineering

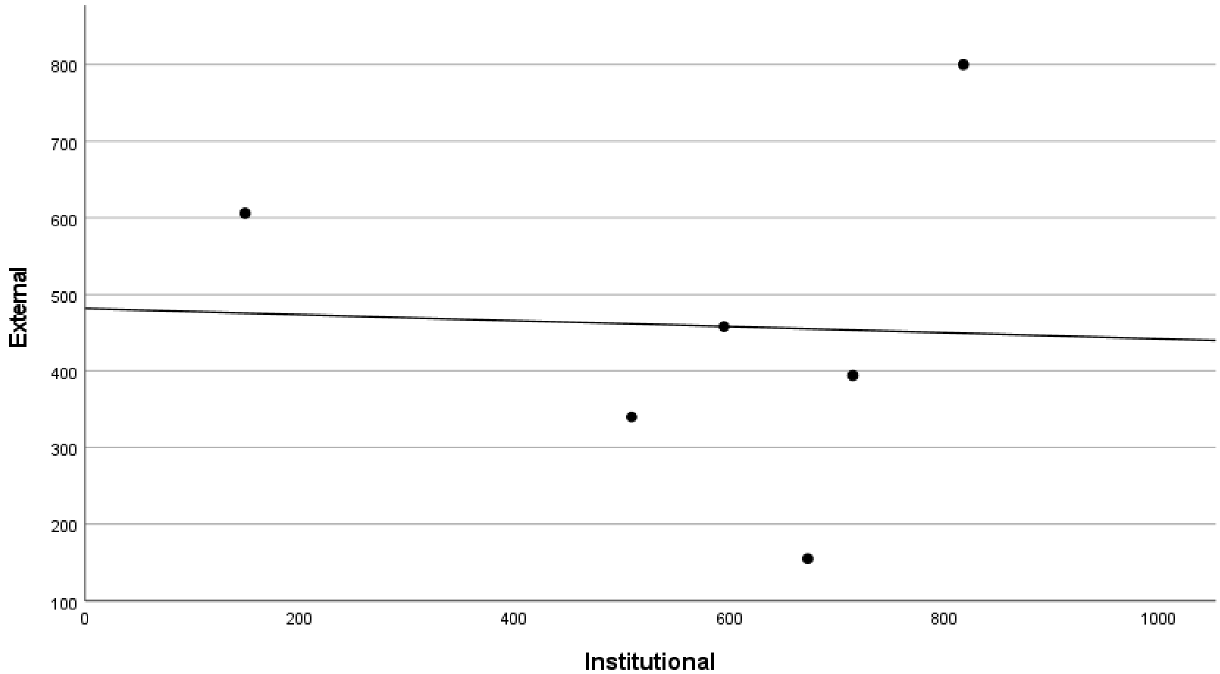


Figure 2.142

Normal Q-Q Plot of External for Mechanical Engineering

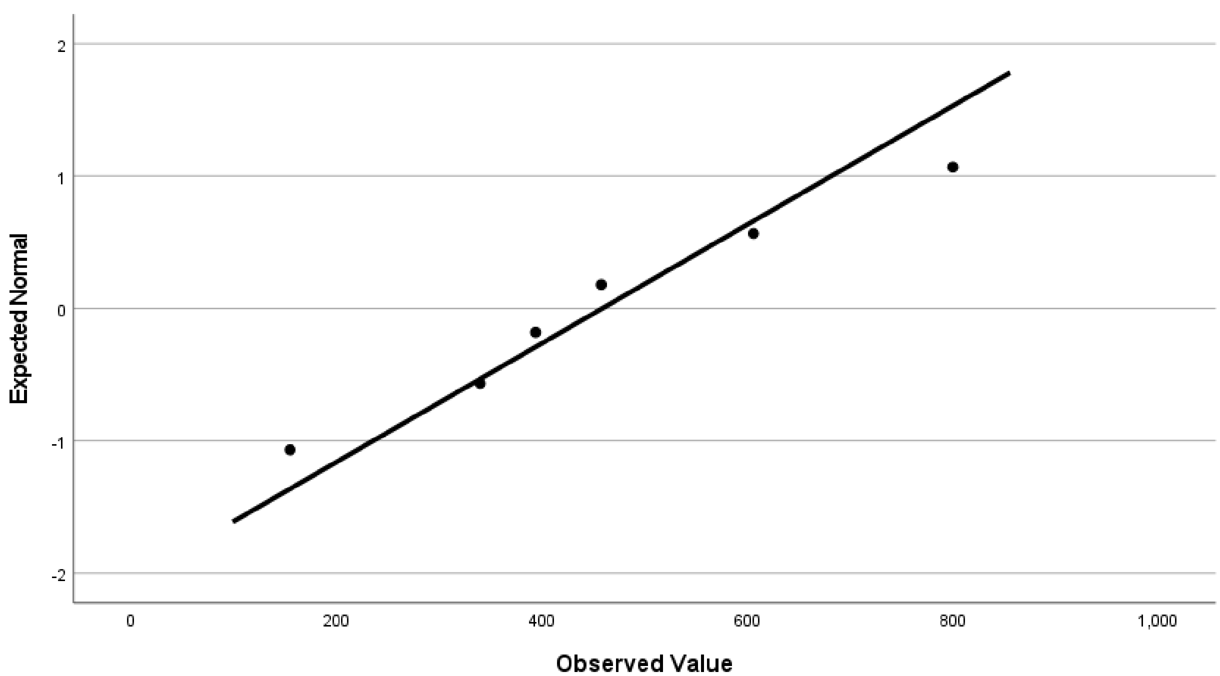


Figure 2.143

Normal P-P Plot of Regression Standardized Residual for Mechanical Engineering

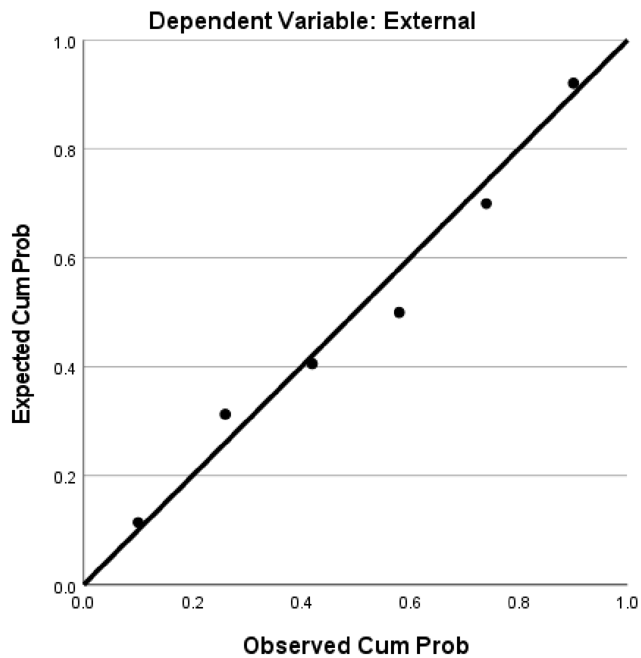
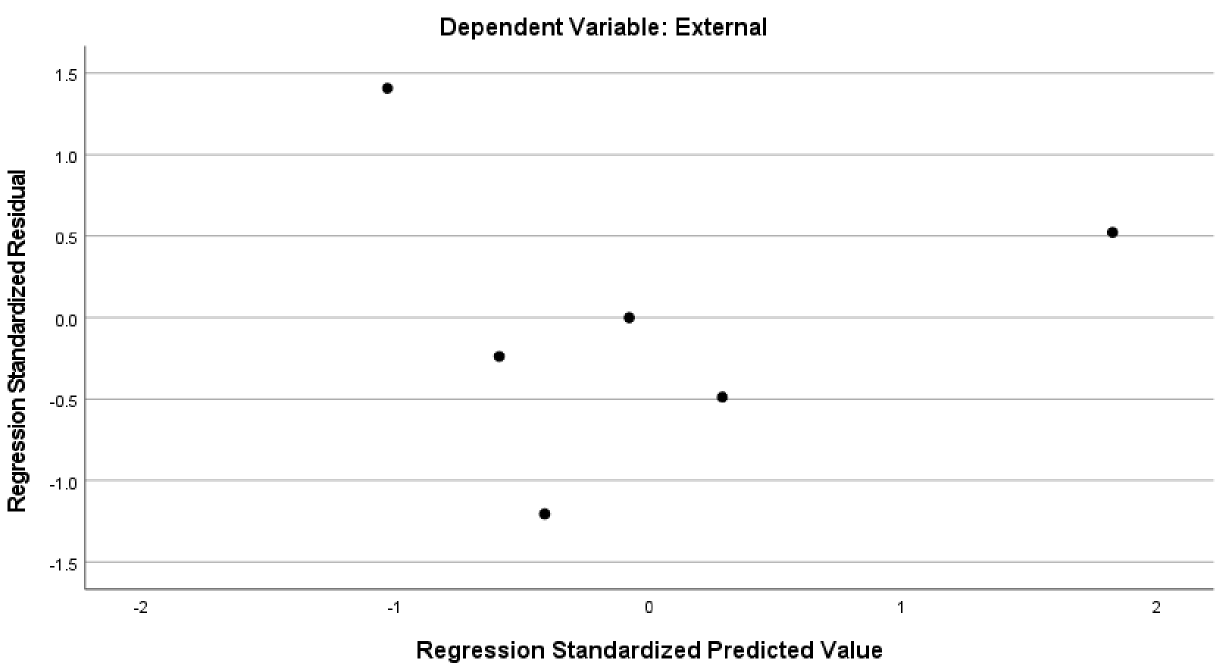


Figure 2.144

Scatterplot for Mechanical Engineering



Other Engineering

The NSF HERD Survey (n.d.) categorizes any Engineering fields that cannot be specifically identified within the previously listed subfields as Other Engineering. Table 2.37 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Engineering R&D expenditures. Figure 2.145 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Engineering subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.146. Standardized residuals were not normally distributed as shown in Figure 2.147. Scatterplots in Figure 2.148 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Engineering subfield, $F(1,4) = 2.99$, $p = .159$. A large effect size was noted with approximately 42.7% of the variances accounted for in the model, $R^2 = .427$.

Table 2.37

Descriptive Statistics for Other Engineering (n = 6 and r = -0.65)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	945
2015	1816	722
2016	1625	468
2017	998	713
2018	1452	451
2019	1519	200
2020	7589	-
M	2499.83	583.17
SD	2507.91	262.53

Figure 2.145

Scatter Plot of External by Institutional for Other Engineering

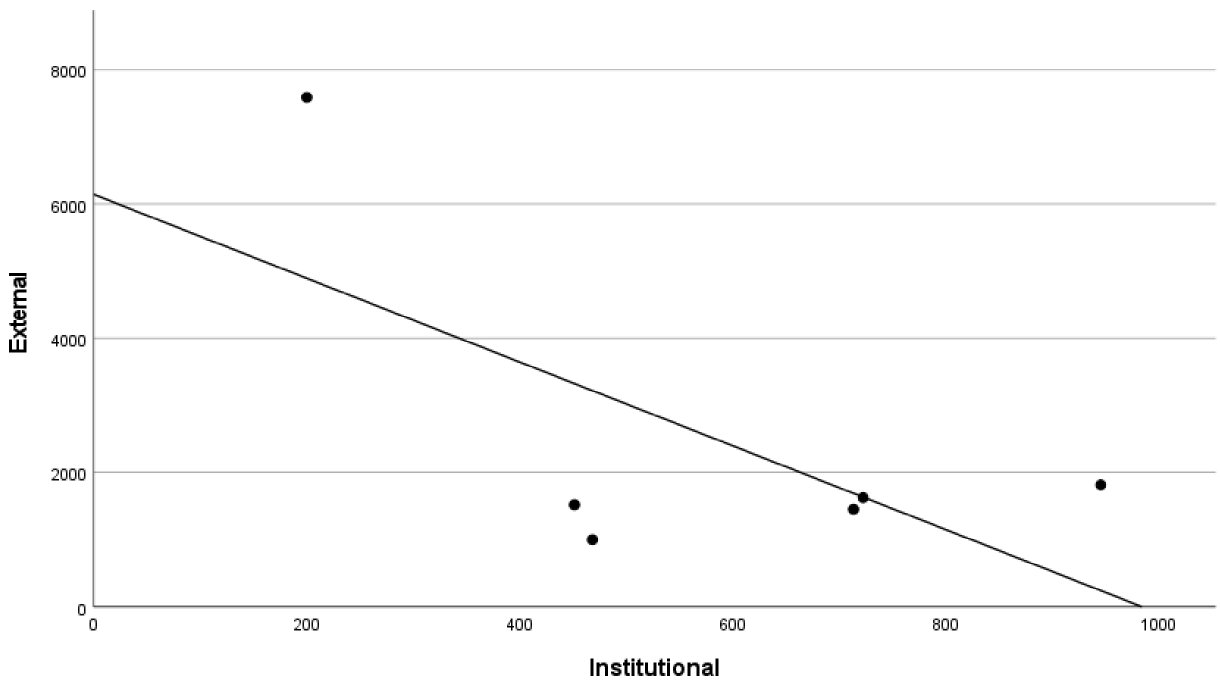


Figure 2.146

Normal Q-Q Plot of External for Other Engineering

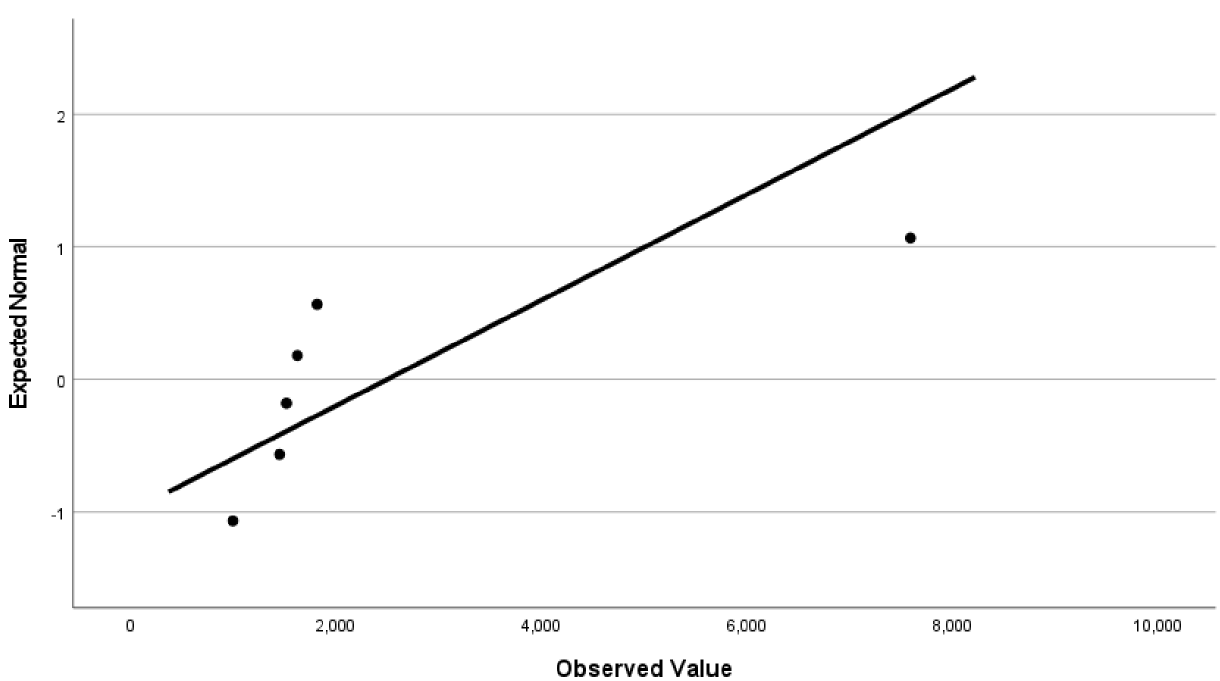


Figure 2.147

Normal P-P Plot of Regression Standardized Residual for Other Engineering

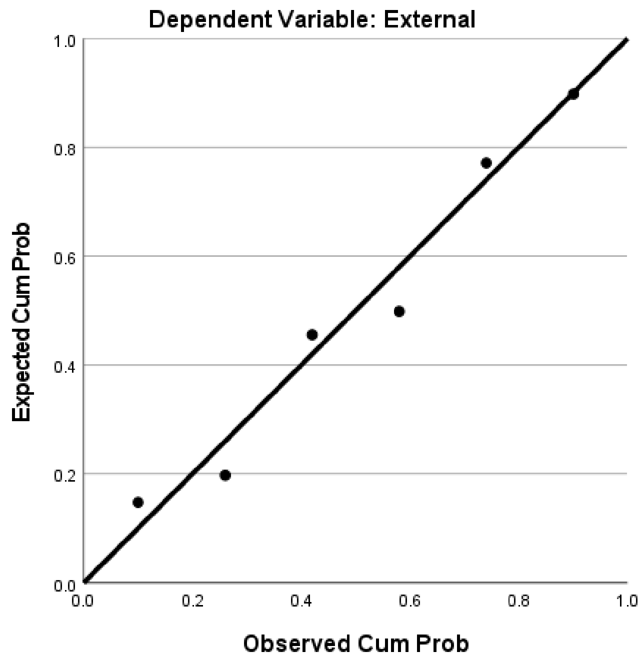
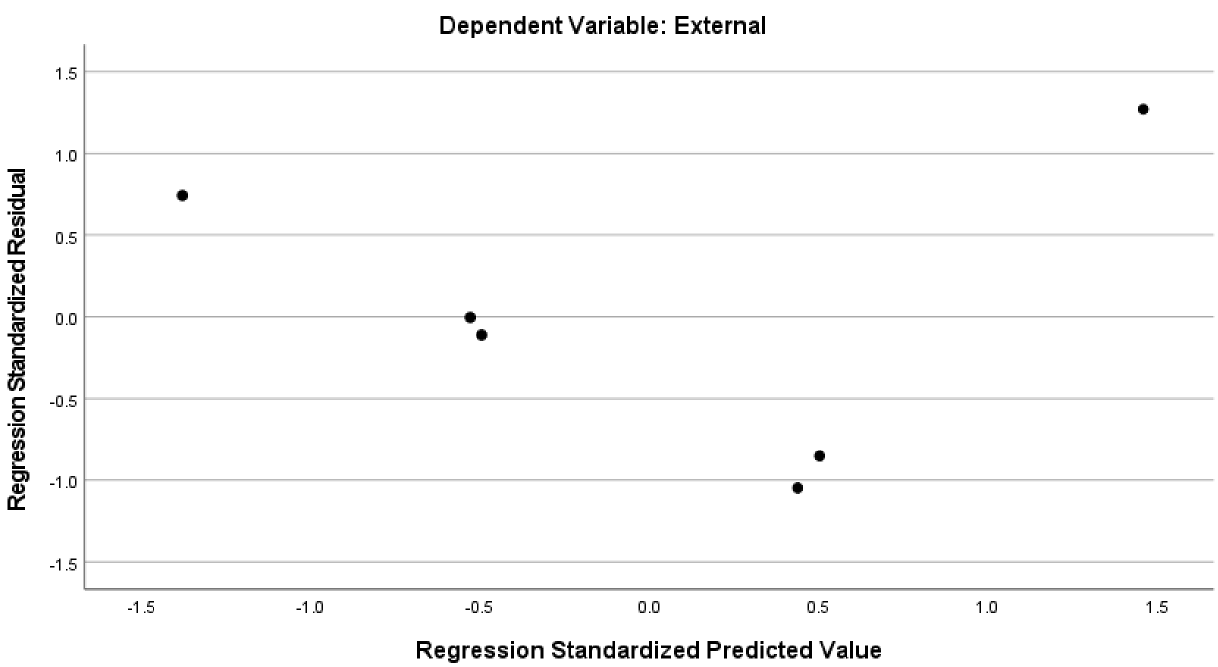


Figure 2.148

Scatterplot for Other Engineering



Geosciences, Atmospheric Sciences, and Ocean Sciences

Table 2.38 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Geosciences, Atmospheric Sciences, and Ocean (GAS&O) Sciences R&D expenditures. Figure 2.149 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Geosciences, Atmospheric Sciences, and Ocean Sciences field reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.150. Standardized residuals were not normally distributed as shown in Figure 2.151. Scatterplots in Figure 2.152 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Geosciences, Atmospheric Sciences, and Ocean Sciences field, $F(1,4) = .83$, $p = .415$. A medium effect size was noted with approximately 17.1% of the variances accounted for in the model, $R^2 = .171$.

Table 2.38

Descriptive Statistics for GAS&O Sciences (n = 6 and r = -0.41)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	605
2015	7729	457
2016	2355	821
2017	1000	678
2018	1132	665
2019	964	762
2020	648	-
M	2304.67	664.67
SD	2721.95	127.10

Figure 2.149

Scatter Plot of External by Institutional for GAS&O Sciences

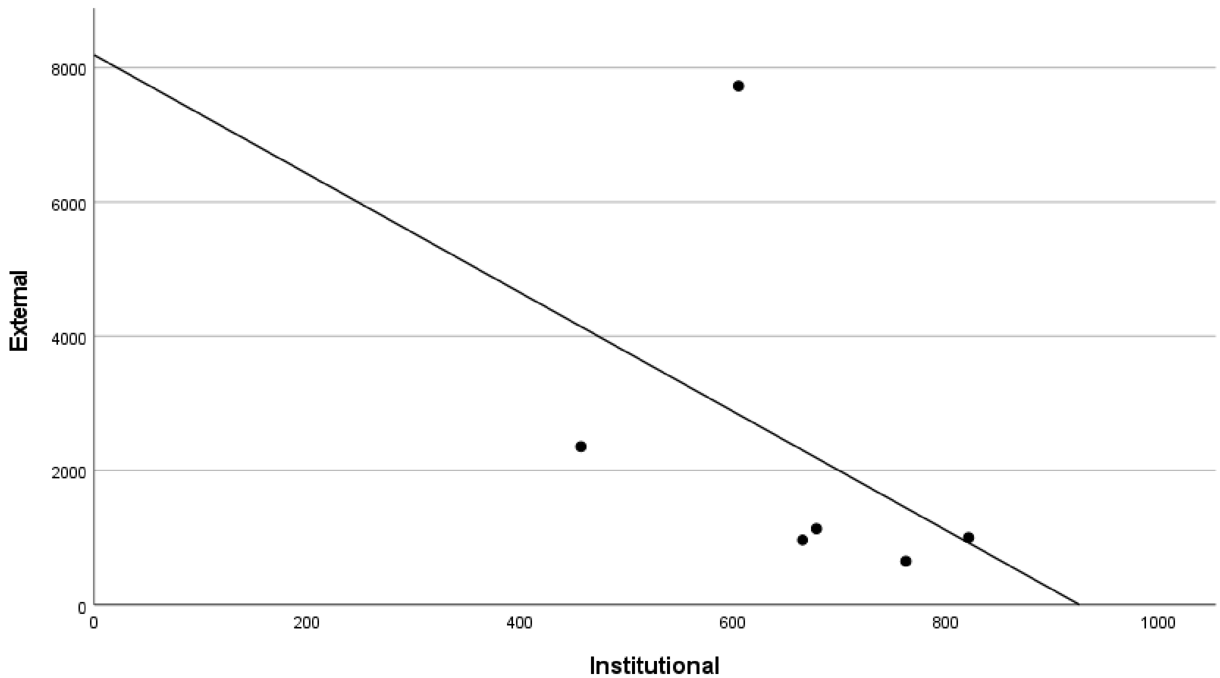


Figure 2.150

Normal Q-Q Plot of External for GAS&O Sciences

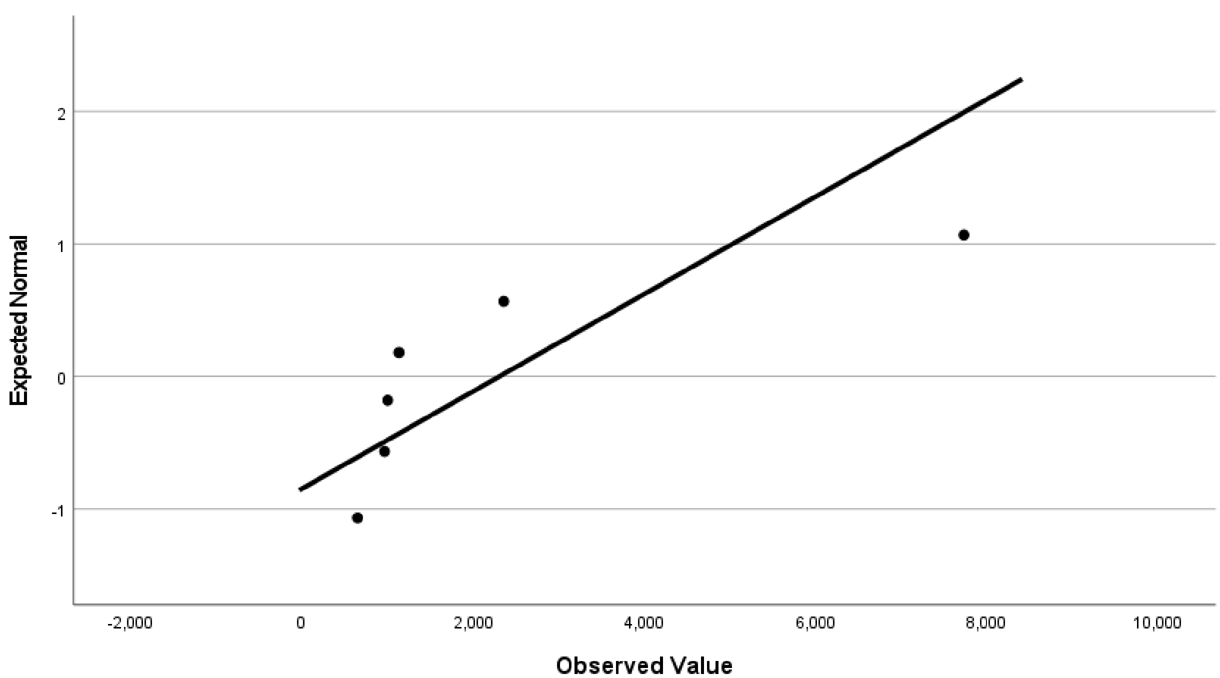


Figure 2.151

Normal P-P Plot of Regression Standardized Residual for GAS&O Sciences

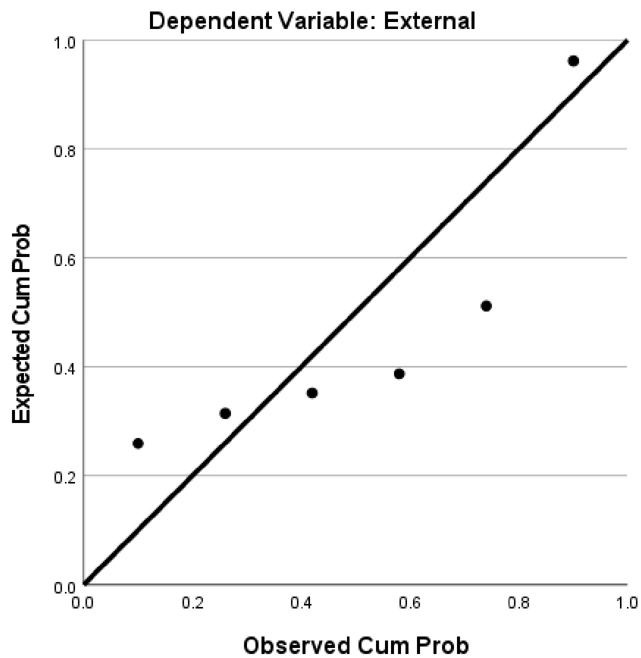
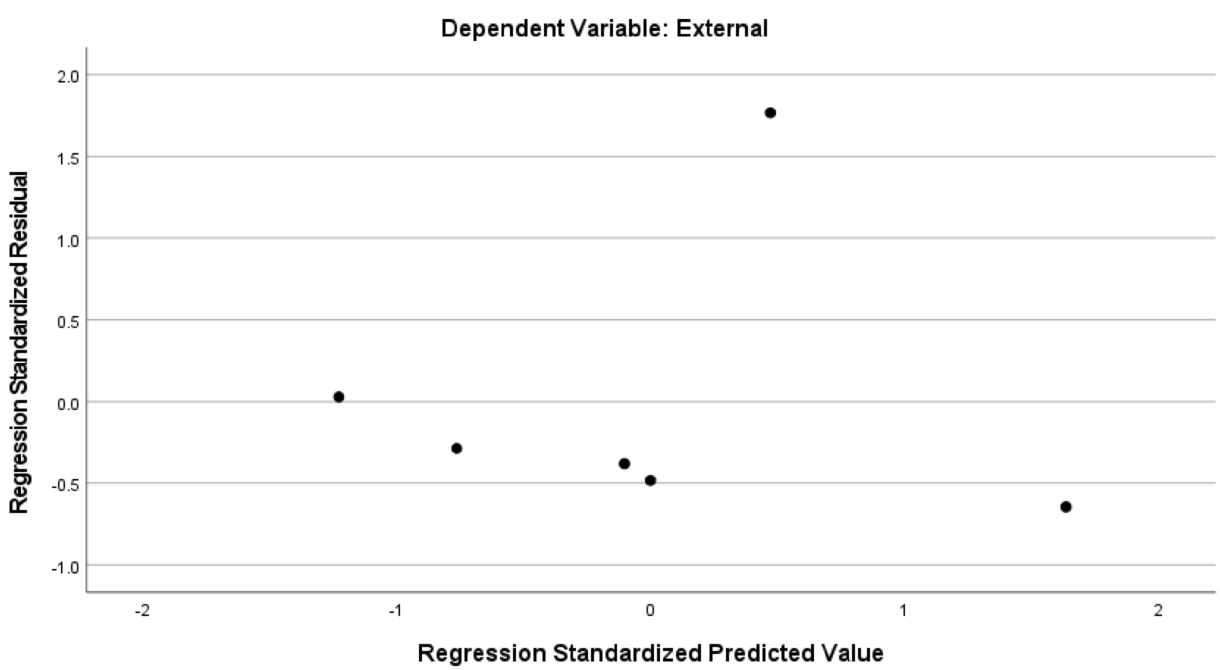


Figure 2.152

Scatterplot for GAS&O Sciences



Geological and Earth Sciences

Table 2.39 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Geological and Earth Sciences R&D expenditures. Figure 2.153 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Geological and Earth Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.154. Standardized residuals were somewhat normally distributed as shown in Figure 2.155 as most of the values fall closely on the line. Scatterplots in Figure 2.156 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Geological and Earth Sciences subfield, $F(1,4) = 1.92$, $p = .238$. A large effect size was noted with approximately 32.4% of the variances accounted for in the model, $R^2 = .324$.

Table 2.39

Descriptive Statistics for Geological and Earth Sciences (n = 6 and r = 0.57)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	66
2015	70	84
2016	36	380
2017	208	492
2018	219	529
2019	187	615
2020	79	-
M	133.17	361.00
SD	80.29	234.10

Figure 2.153

Scatter Plot of External by Institutional for Geological and Earth Sciences

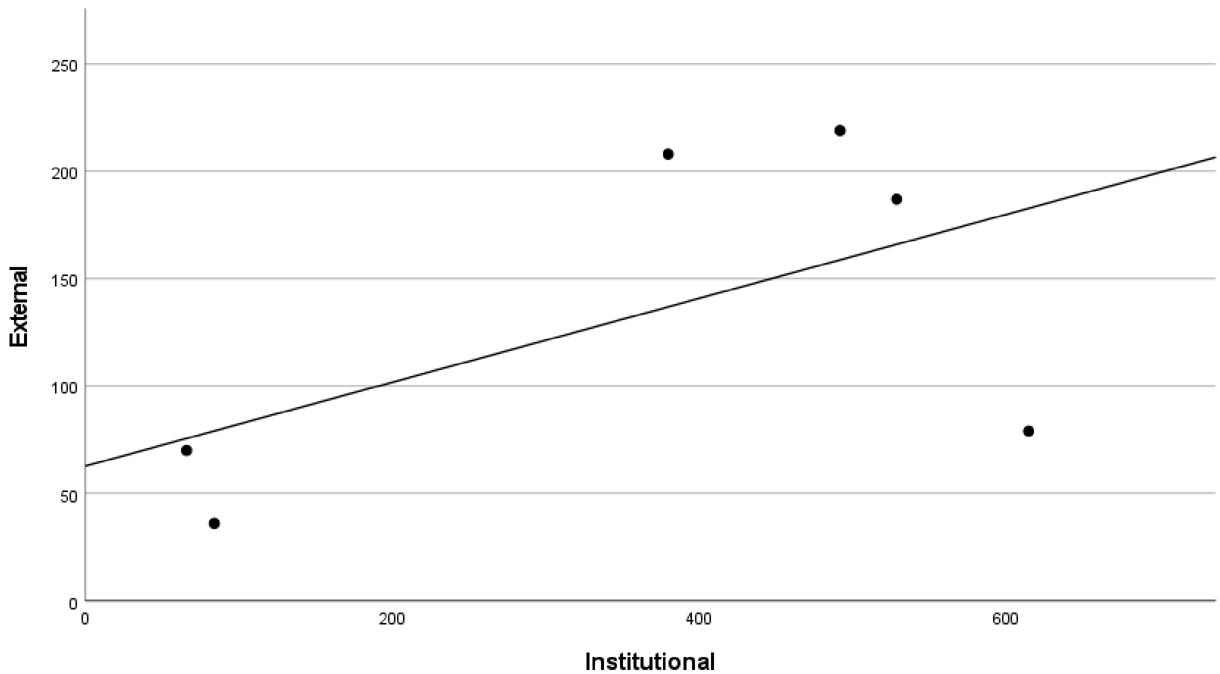


Figure 2.154

Normal Q-Q Plot of External for Geological and Earth Sciences

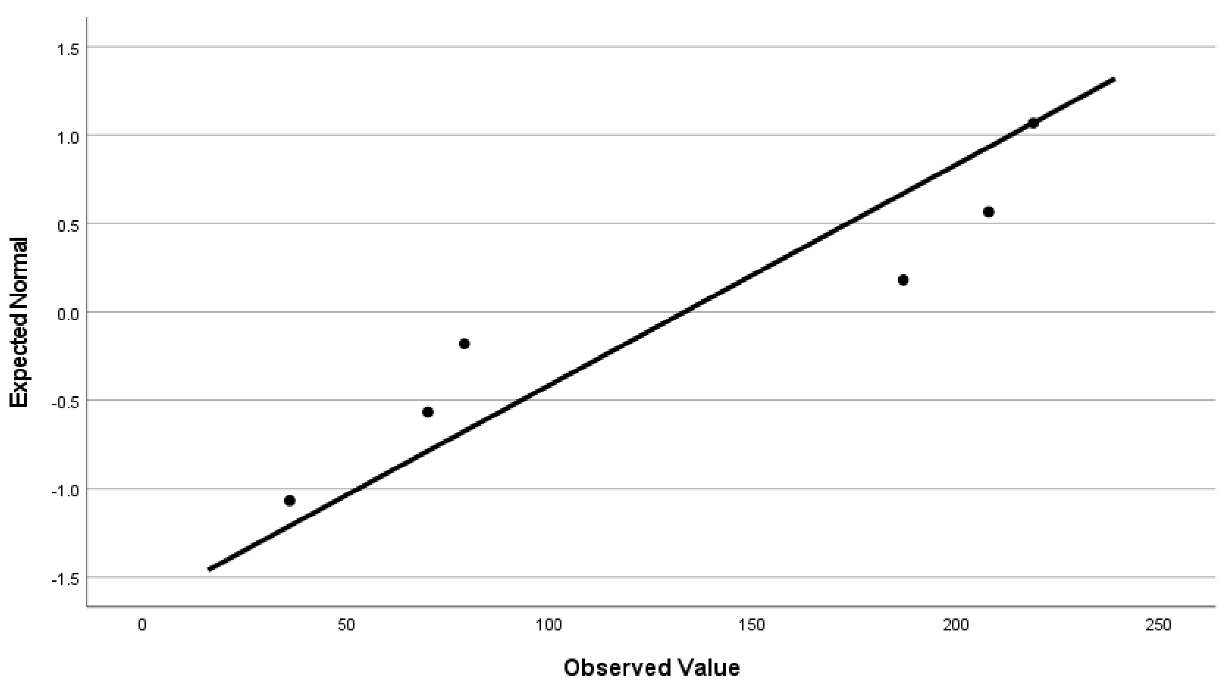


Figure 2.155

Normal P-P Plot of Regression Standardized Residual for Geological and Earth Sciences

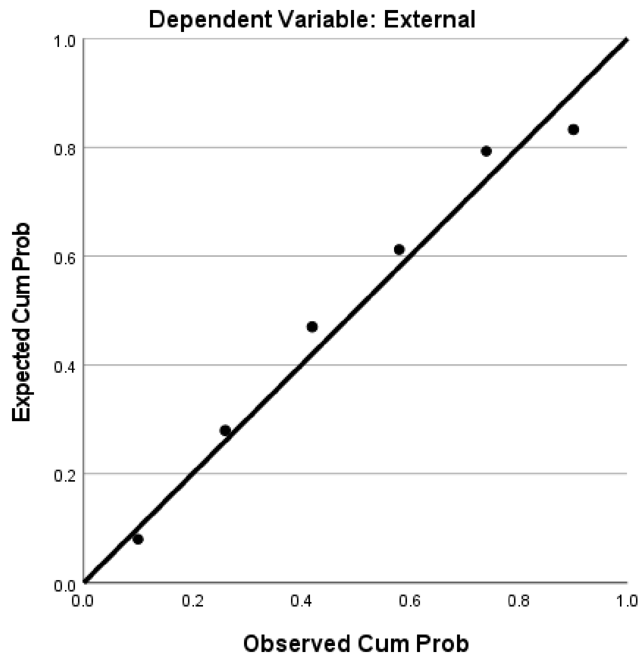
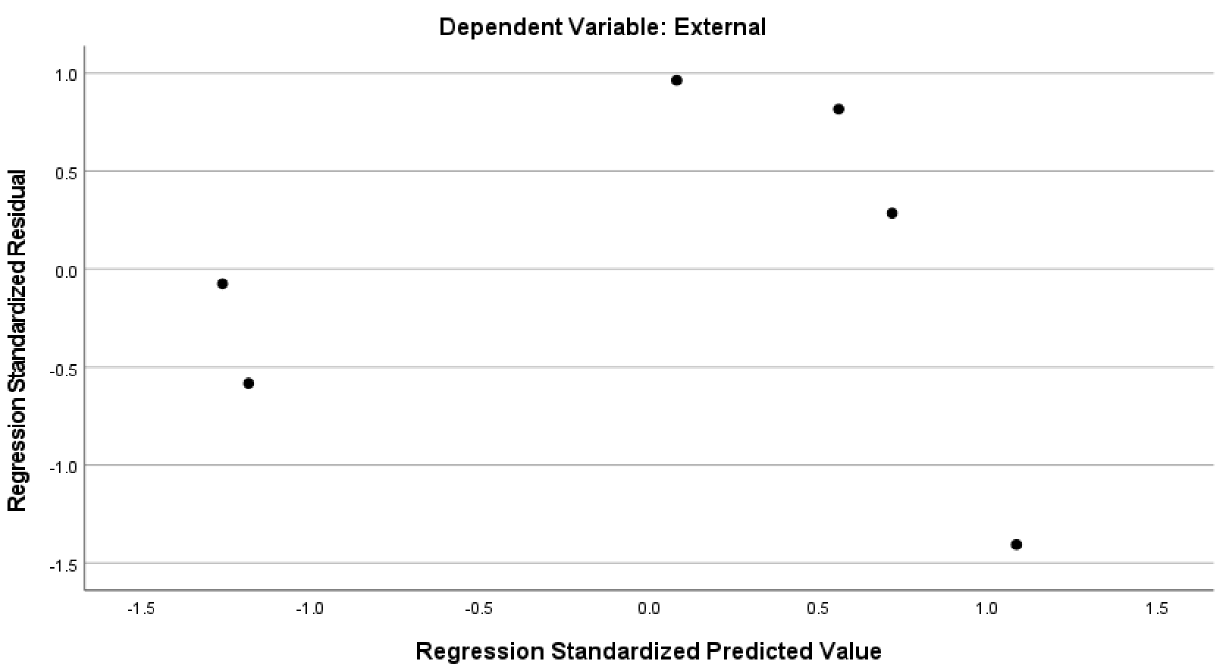


Figure 2.156

Scatterplot for Geological and Earth Sciences



Ocean Sciences and Marine Sciences

Table 2.40 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Ocean Sciences and Marine Sciences R&D expenditures. Figure 2.157 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Ocean Sciences and Marine Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.158. Standardized residuals were not normally distributed as shown in Figure 2.159. Scatterplots in Figure 2.160 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Ocean Sciences and Marine Sciences subfield, $F(1,4) = 4.78$, $p = .094$. A large effect size was noted with approximately 54.4% of the variances accounted for in the model, $R^2 = .544$.

Table 2.40

Descriptive Statistics for Ocean Sciences and Marine Sciences (n = 6 and r = 0.74)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	539
2015	7659	373
2016	2319	441
2017	654	185
2018	683	136
2019	777	147
2020	481	-
M	2095.50	303.50
SD	2807.87	170.76

Figure 2.157

Scatter Plot of External by Institutional for Ocean Sciences and Marine Sciences

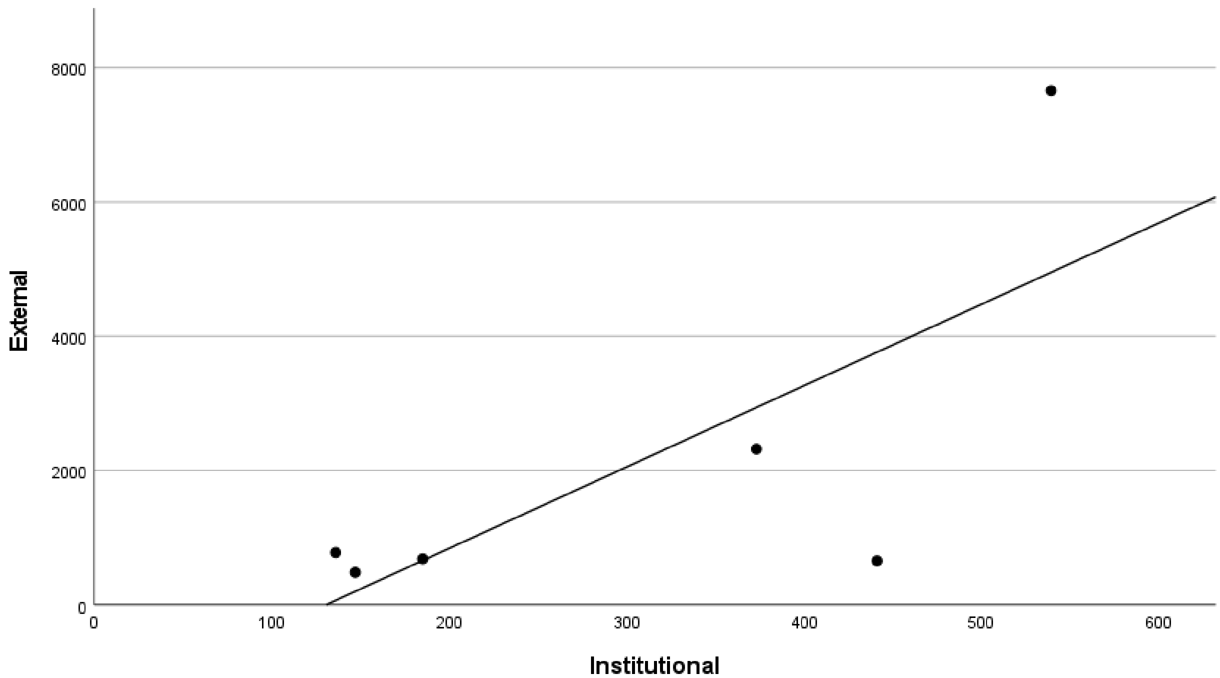


Figure 2.158

Normal Q-Q Plot of External for Ocean Sciences and Marine Sciences

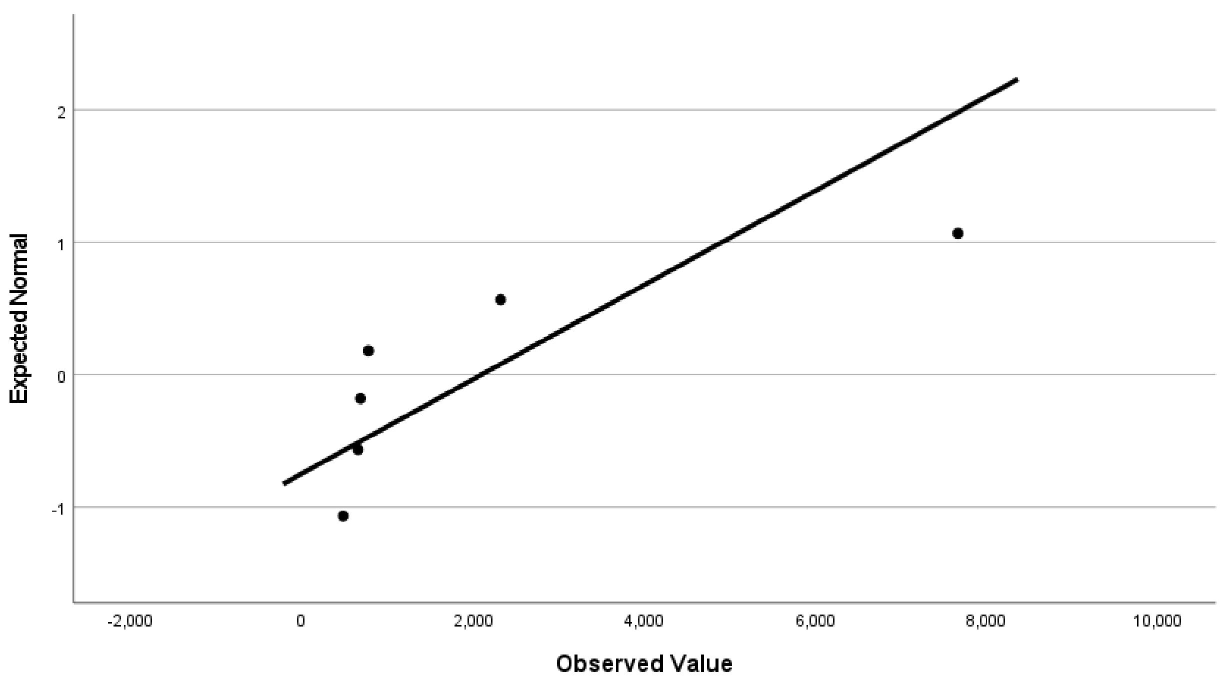


Figure 2.159

Normal P-P Plot of Regression Standardized Residual for Ocean Sciences and Marine Sciences

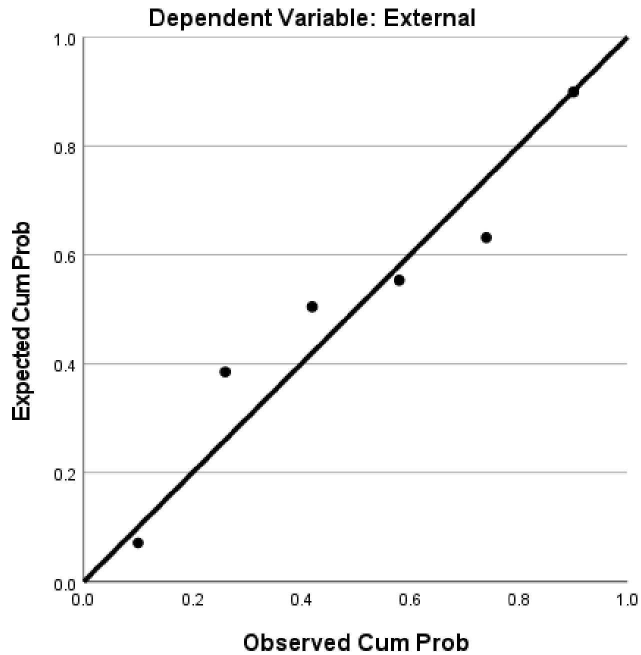
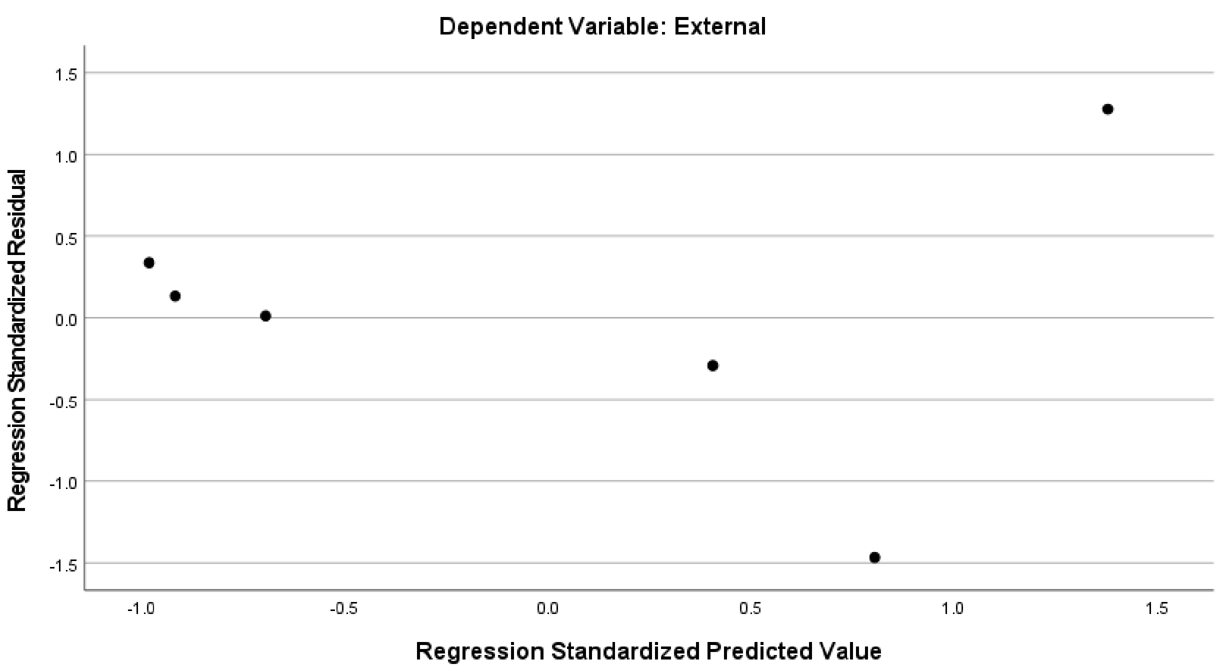


Figure 2.160

Scatterplot for Ocean Sciences and Marine Sciences



Life Sciences

Table 2.41 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Life Sciences R&D expenditures. Figure 2.161 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Life Sciences field reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.162. Standardized residuals were not normally distributed as shown in Figure 2.163. Scatterplots in Figure 2.164 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a statistically significant relationship between institutionally and externally funded R&D expenditures in the Life Sciences field, $F(1,4) = 15.94$, $p = .016$. A large effect size was noted with approximately 79.9% of the variances accounted for in the model, $R^2 = .799$.

Table 2.41

Descriptive Statistics for Life Sciences (n = 6 and r = 0.89)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	9398
2015	54635	9990
2016	57669	14829
2017	55538	28445
2018	58733	32518
2019	66678	37204
2020	69196	16933
M	60408.17	22064.00
SD	6064.55	12147.24

Figure 2.161

Scatter Plot of External by Institutional for Life Sciences

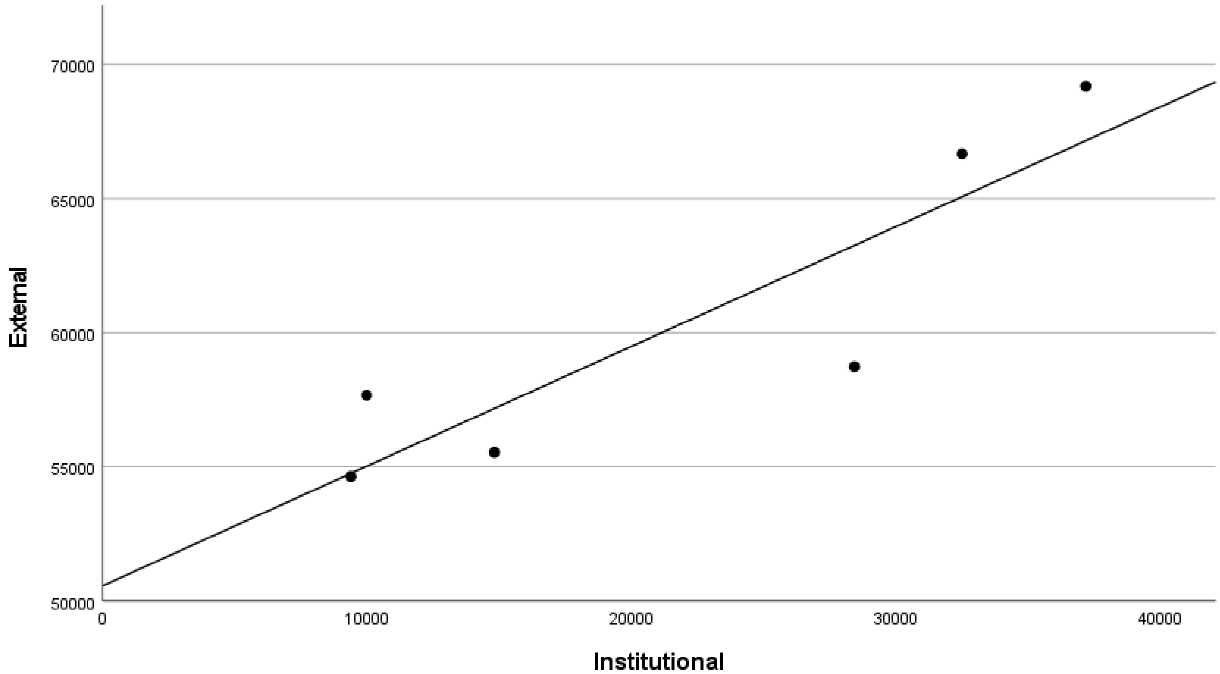


Figure 2.162

Normal Q-Q Plot of External for Life Sciences

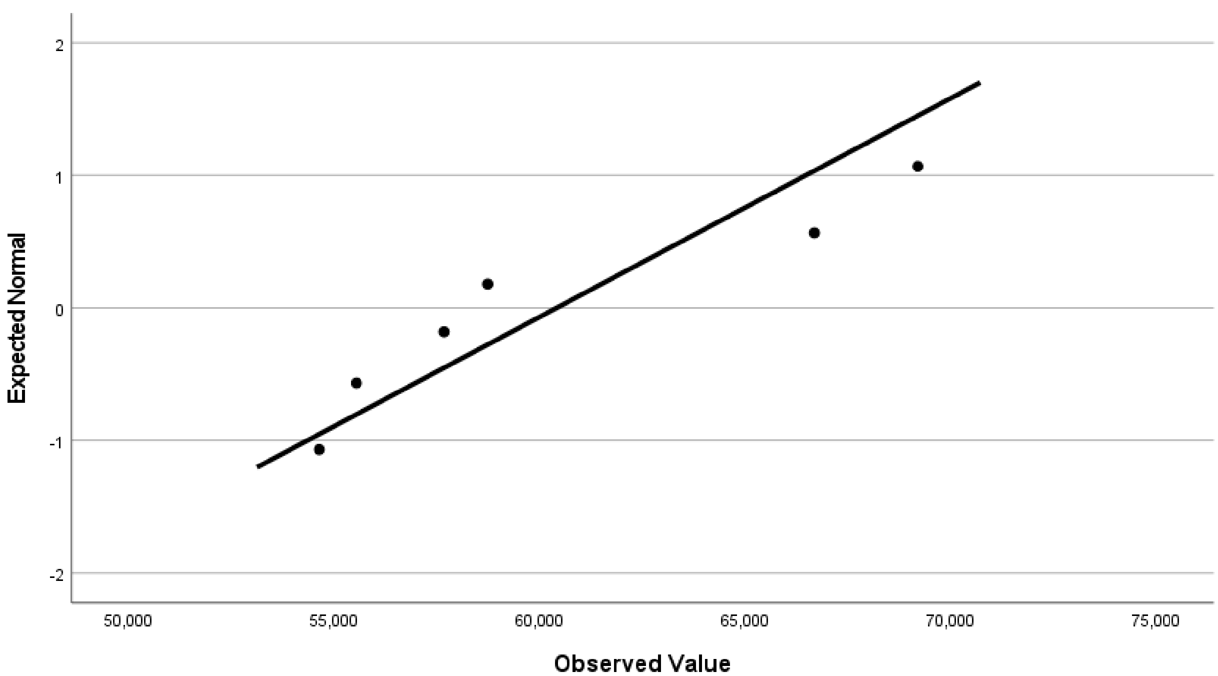


Figure 2.163

Normal P-P Plot of Regression Standardized Residual for Life Sciences

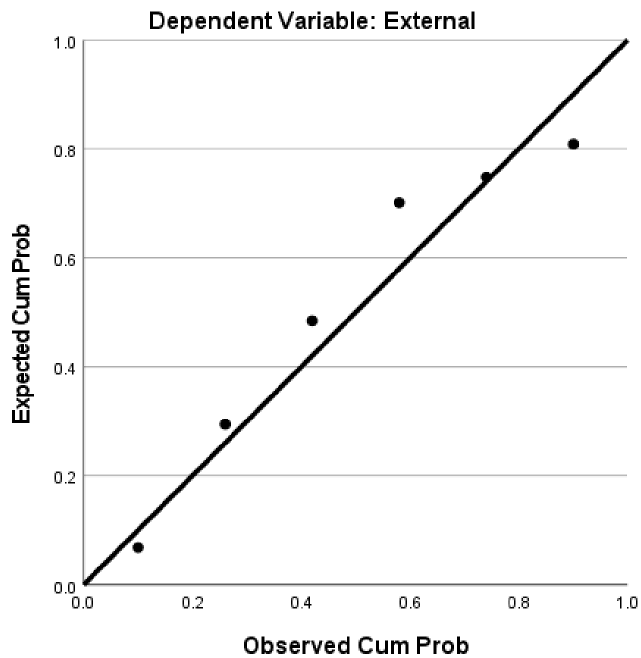
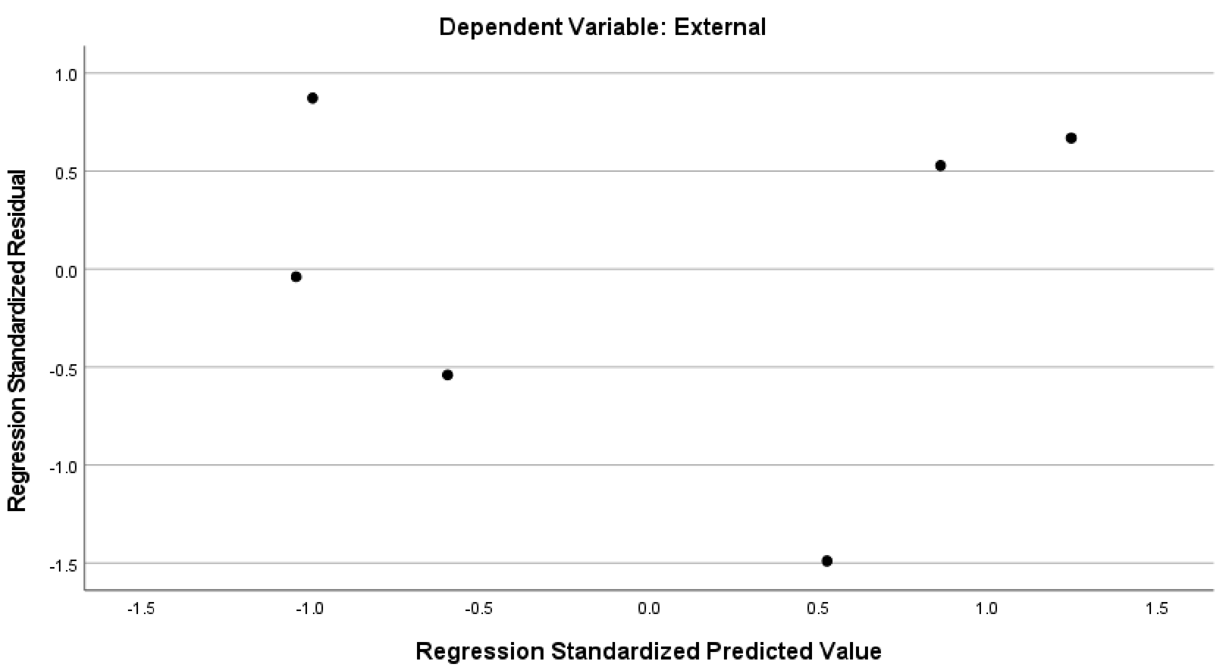


Figure 2.164

Scatterplot for Life Sciences



Biological and Biomedical Sciences

Table 2.42 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Biological and Biomedical Sciences R&D expenditures. Figure 2.165 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Biological and Biomedical Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.166 as half of the values fall closely on the line. Standardized residuals were not normally distributed as shown in Figure 2.167. Scatterplots in Figure 2.168 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Biological and Biomedical Sciences subfield, $F(1,4) = 2.32$, $p = .202$. A large effect size was noted with approximately 36.7% of the variances accounted for in the model, $R^2 = .367$.

Table 2.42

Descriptive Statistics for Biological and Biomedical Sciences (n = 6 and r = 0.61)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	2005
2015	16058	3133
2016	16062	3747
2017	16978	5280
2018	21994	7299
2019	27714	5680
2020	12348	3518
M	18525.67	4524.00
SD	5462.10	1923.15

Figure 2.165

Scatter Plot of External by Institutional for Biological and Biomedical Sciences

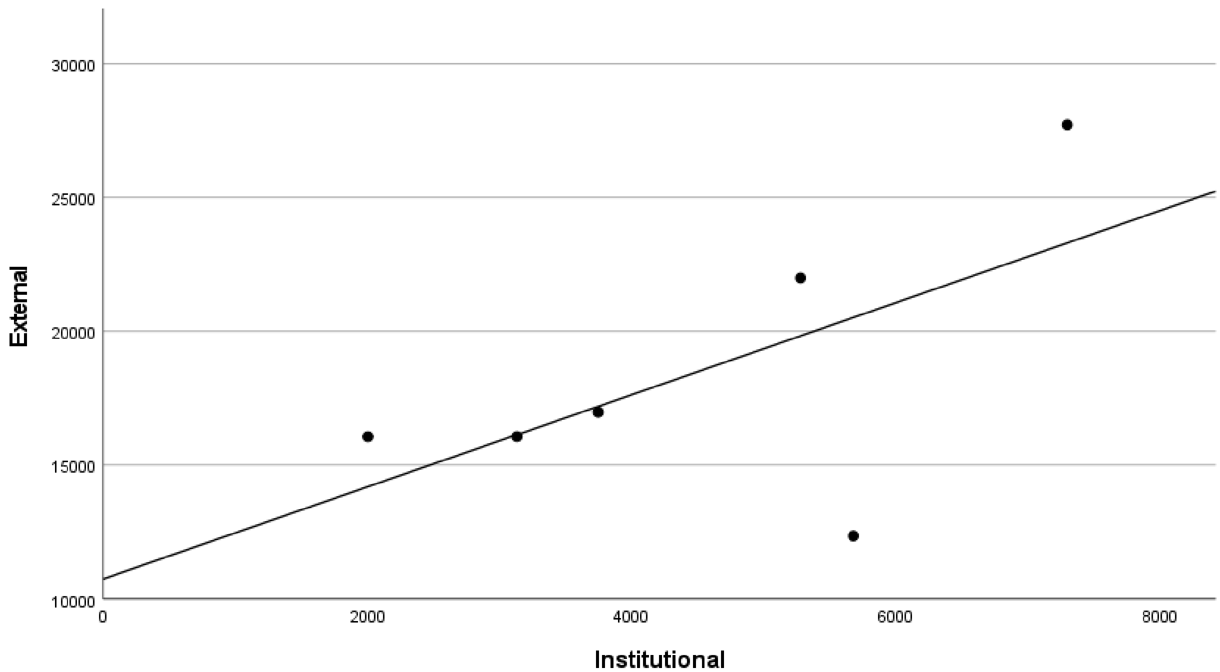


Figure 2.166

Normal Q-Q Plot of External for Biological and Biomedical Sciences

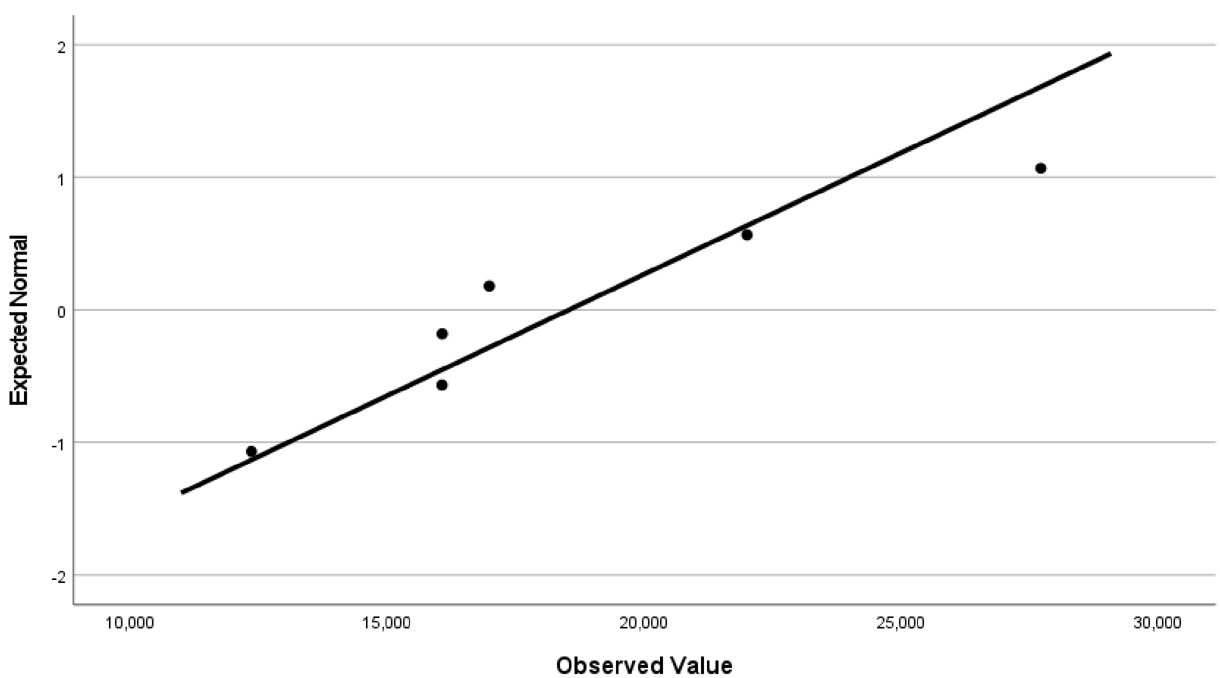


Figure 2.167

Normal P-P Plot of Regression Standardized Residual for Biological and Biomedical Sciences

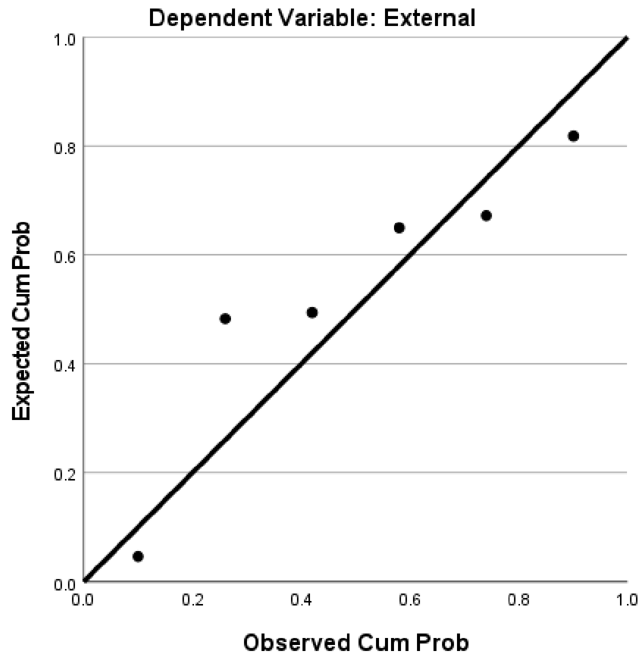
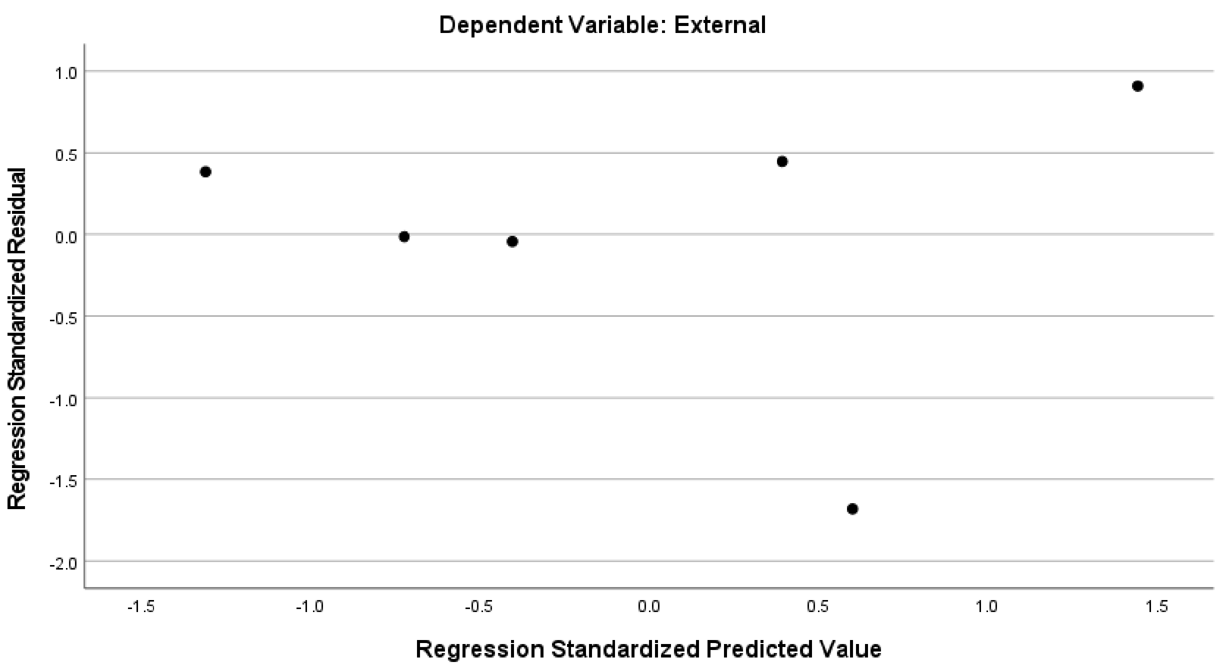


Figure 2.168

Scatterplot for Biological and Biomedical Sciences



Health Sciences

Table 2.43 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Health Sciences R&D expenditures. Figure 2.169 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Health Sciences subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.170. Standardized residuals were not normally distributed as shown in Figure 2.171. Scatterplots in Figure 2.172 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Health Sciences subfield, $F(1,4) = .93$, $p = .390$. A medium effect size was noted with approximately 18.8% of the variances accounted for in the model, $R^2 = .188$.

Table 2.43

Descriptive Statistics for Health Sciences (n = 6 and r = 0.43)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	6777
2015	36252	6410
2016	39024	10714
2017	35655	20794
2018	34369	21213
2019	36850	23359
2020	54866	-
M	39502.67	14877.83
SD	7681.45	7768.28

Figure 2.169

Scatter Plot of External by Institutional for Health Sciences

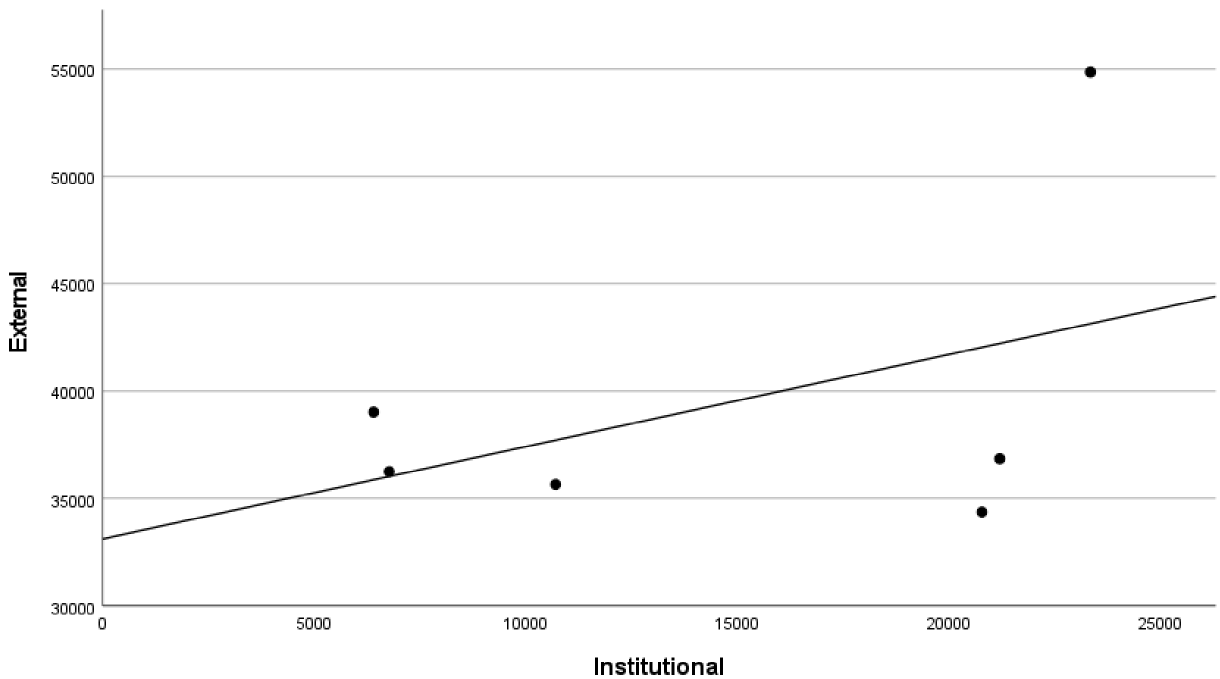


Figure 2.170

Normal Q-Q Plot of External for Health Sciences

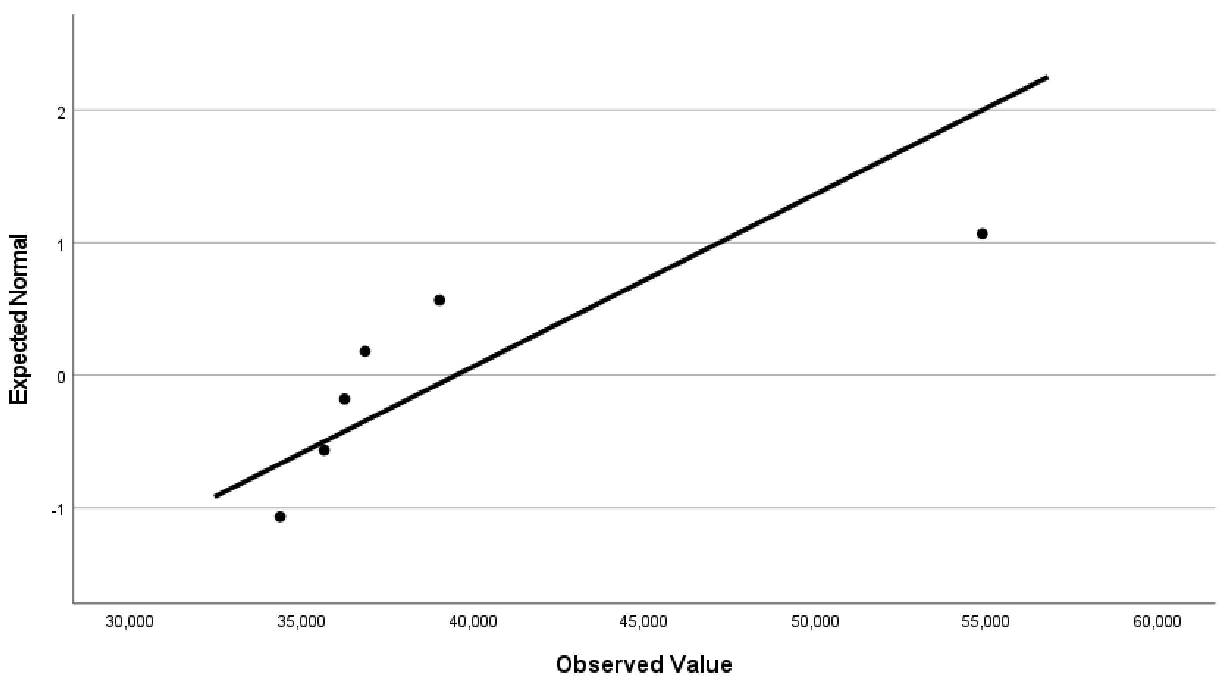


Figure 2.171

Normal P-P Plot of Regression Standardized Residual for Health Sciences

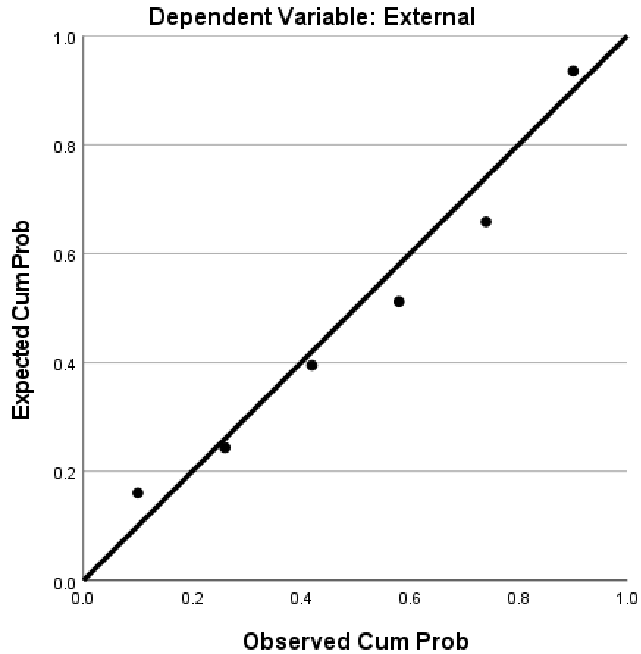
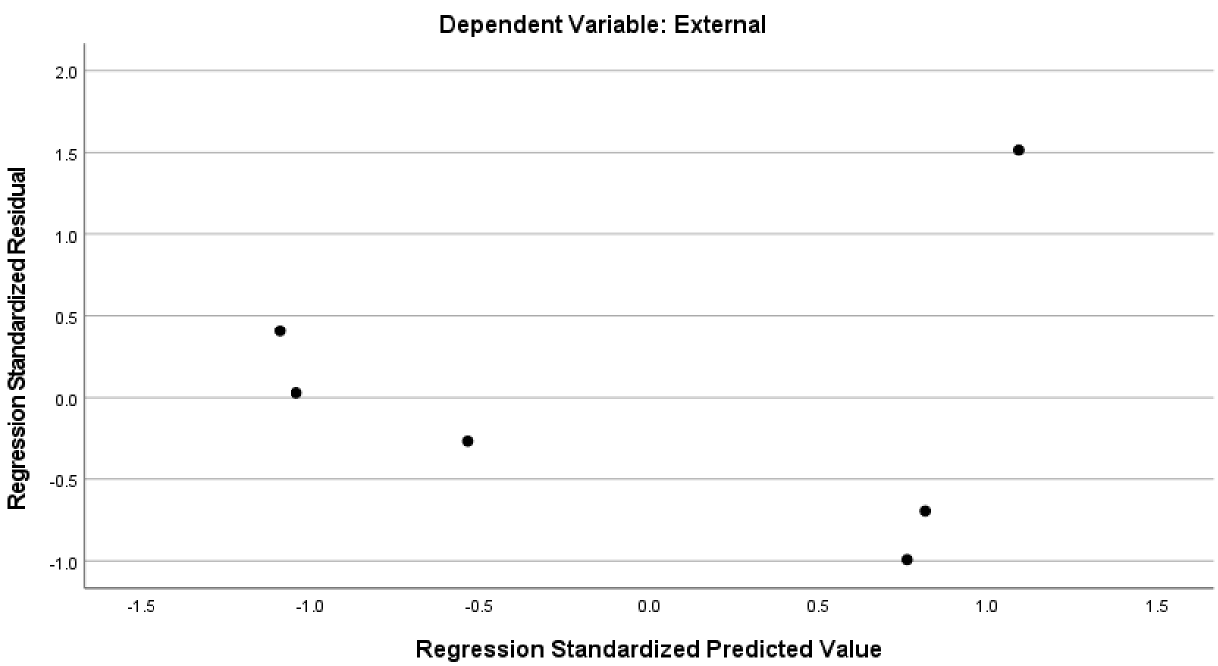


Figure 2.172

Scatterplot for Health Sciences



Other Life Sciences

The NSF HERD Survey (n.d.) categorizes any Life Sciences fields that cannot be specifically identified within the previously listed subfields as Other Life Sciences. Table 2.44 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Life Sciences R&D expenditures. Figure 2.173 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Life Sciences subfield reflecting a negative correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.174, and standardized residuals were somewhat normally distributed as shown in Figure 2.175 as half of the values fall closely on the line. Scatterplots in Figure 2.176 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Life Sciences subfield, $F(1,4) = 10.80$, $p = .030$. A large effect size was noted with approximately 73.0% of the variances accounted for in the model, $R^2 = 0.730$.

Table 2.44

Descriptive Statistics for Other Life Sciences (n = 6 and r = -0.85)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	616
2015	2325	447
2016	2583	368
2017	2890	2366
2018	2361	4003
2019	2114	8165
2020	1886	-
M	2359.83	2660.83
SD	351.30	3050.37

Figure 2.173

Scatter Plot of External by Institutional for Other Life Sciences

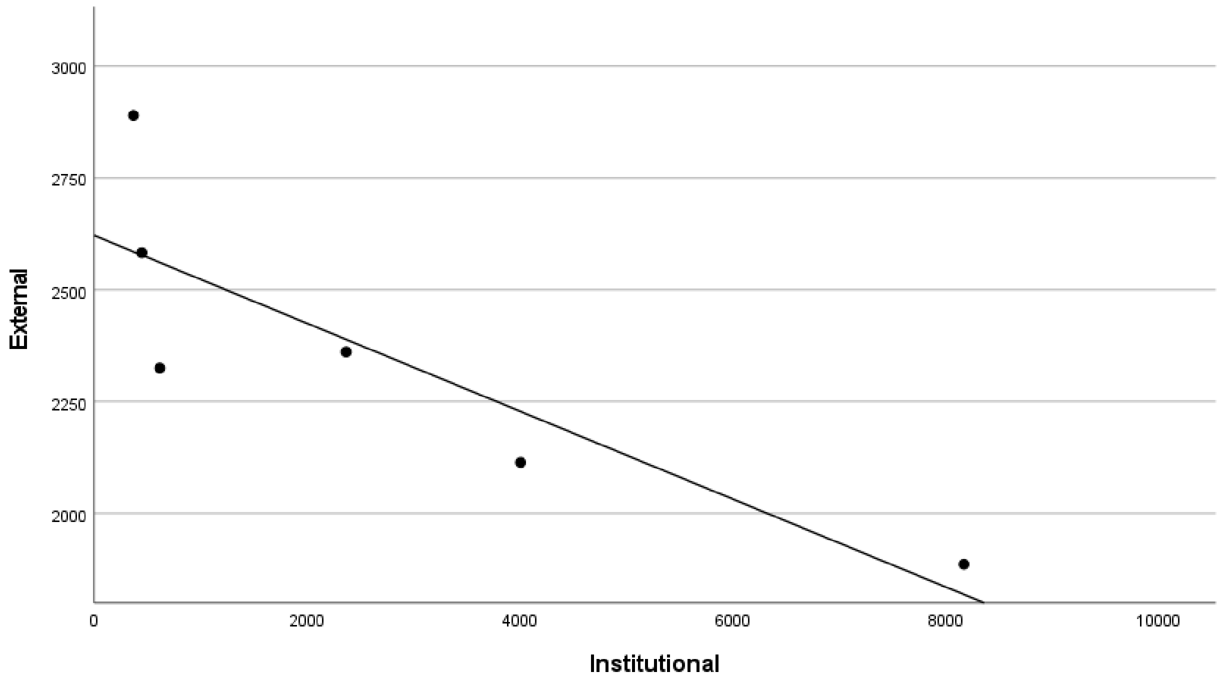


Figure 2.174

Normal Q-Q Plot of External for Other Life Sciences

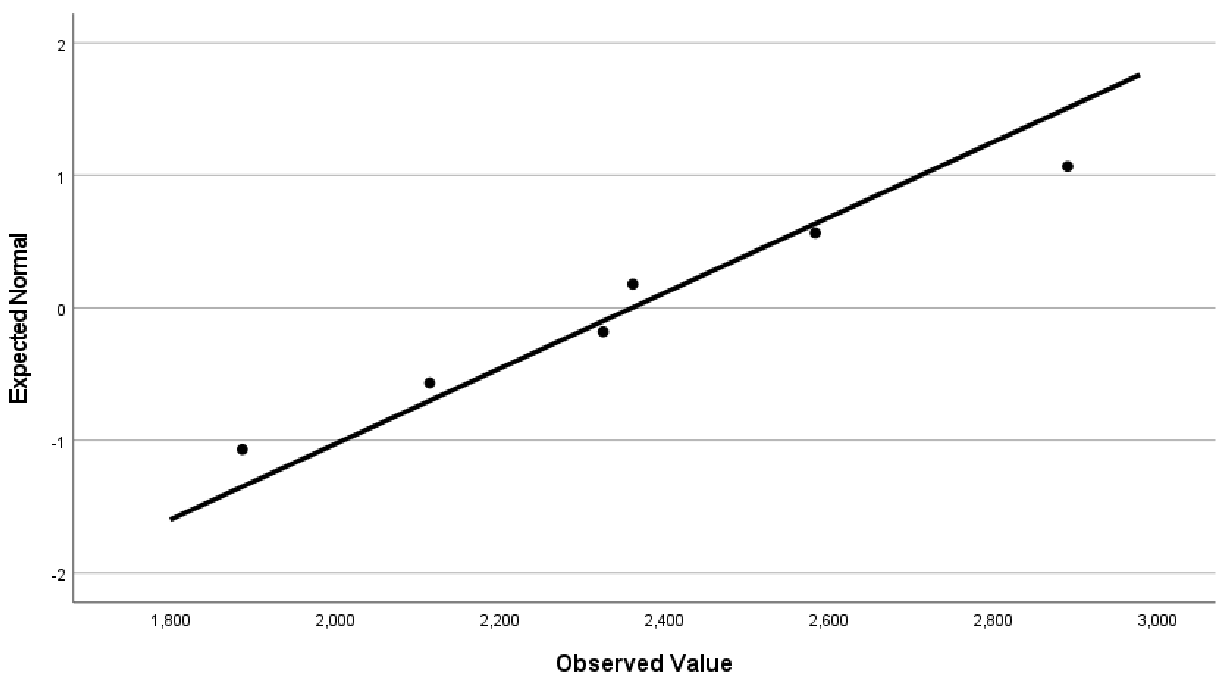


Figure 2.175

Normal P-P Plot of Regression Standardized Residual for Other Life Sciences

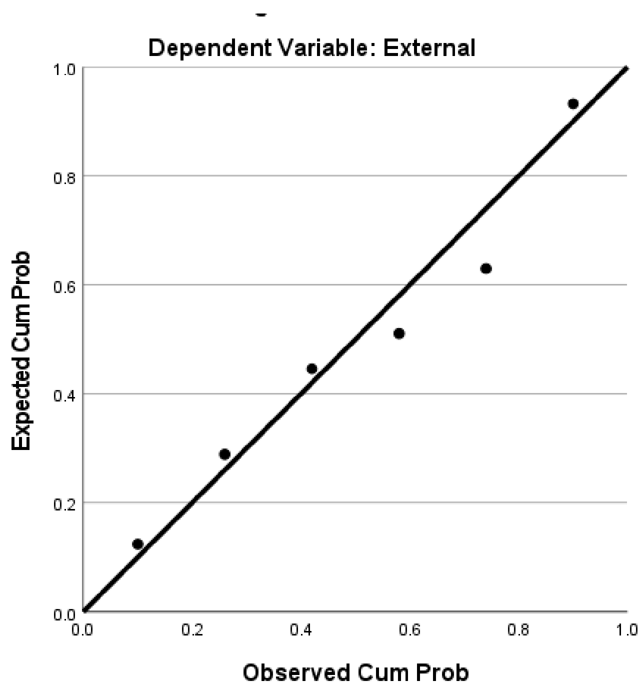
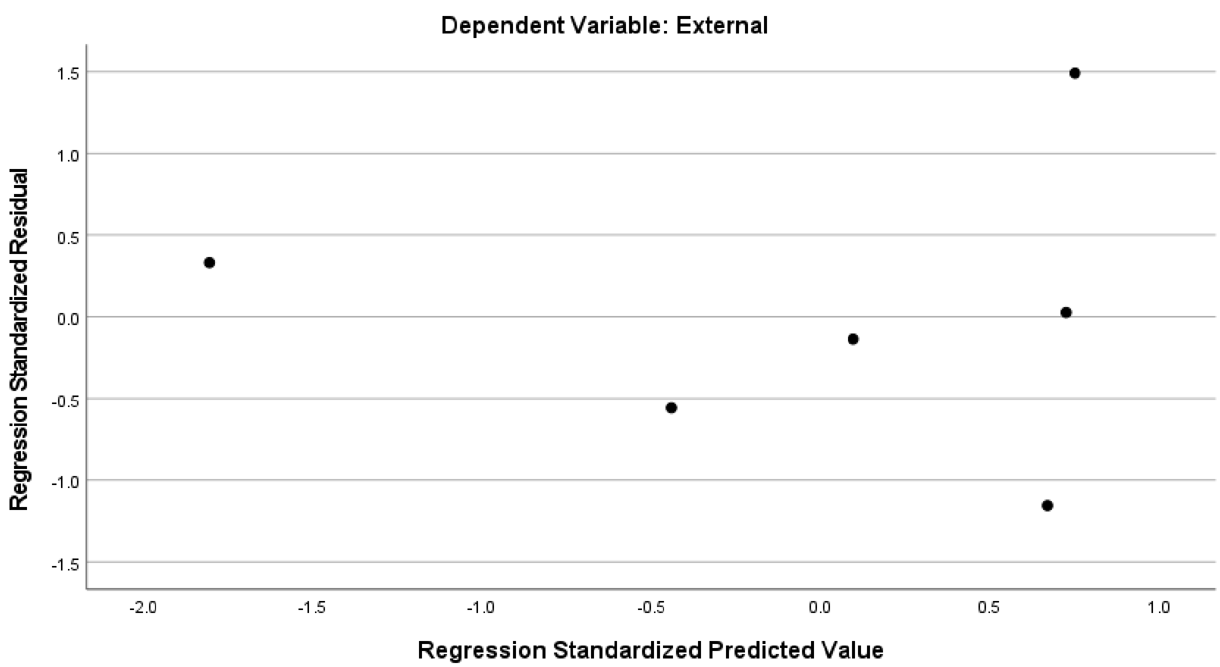


Figure 2.176

Scatterplot for Other Life Sciences



Mathematics and Statistics

Table 2.45 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Mathematics and Statistics R&D expenditures. Figure 2.177 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Mathematics and Statistics field reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.178. Standardized residuals were not normally distributed as shown in Figure 2.179. Scatterplots in Figure 2.180 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Mathematics and Statistics field, $F(1,4) = .09$, $p = .779$. A small effect size was noted with approximately 2.2% of the variances accounted for in the model, $R^2 = .022$.

Table 2.45

Descriptive Statistics for Mathematics and Statistics (n = 6 and r = 0.15)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	264
2015	84	170
2016	22	1041
2017	24	886
2018	143	880
2019	86	1150
2020	56	-
M	69.17	731.83
SD	45.59	412.48

Figure 2.177

Scatter Plot of External by Institutional for Mathematics and Statistics

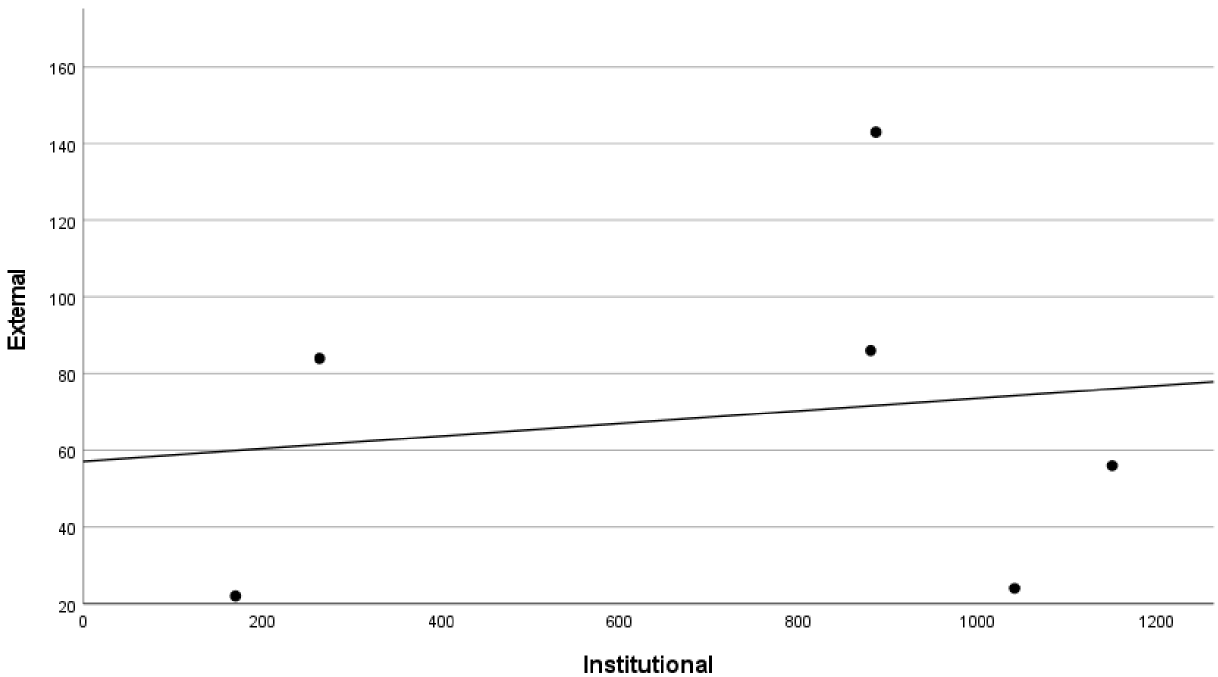


Figure 2.178

Normal Q-Q Plot of External for Mathematics and Statistics

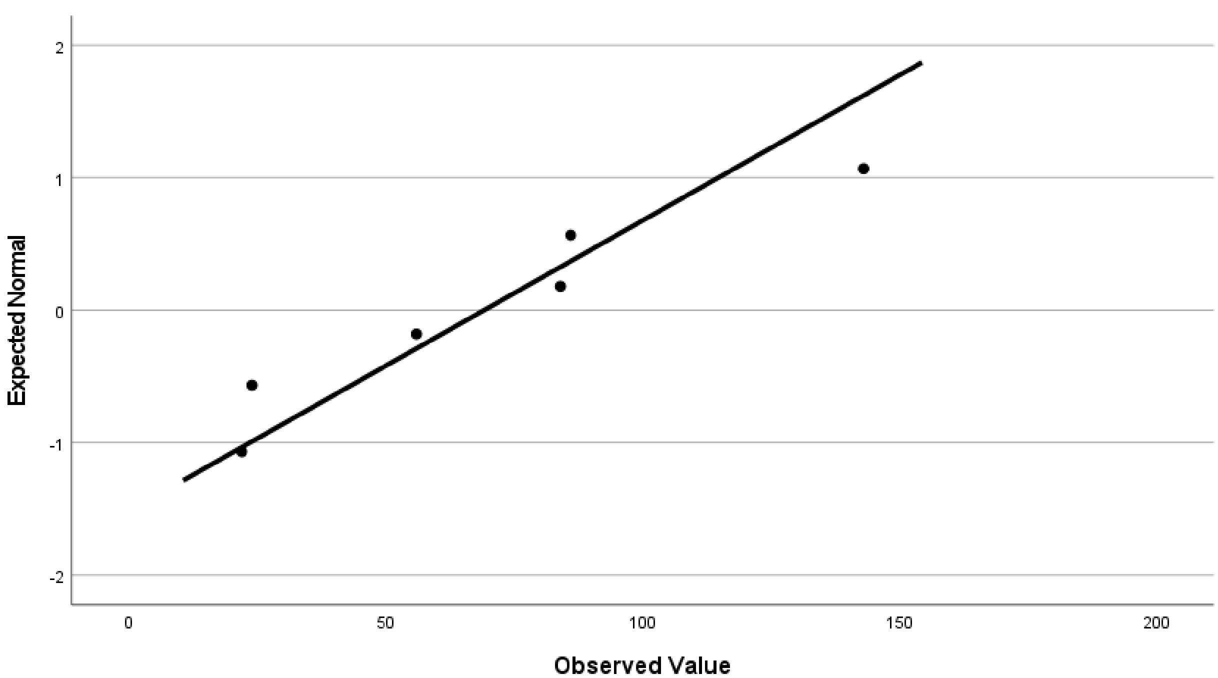


Figure 2.179

Normal P-P Plot of Regression Standardized Residual for Mathematics and Statistics

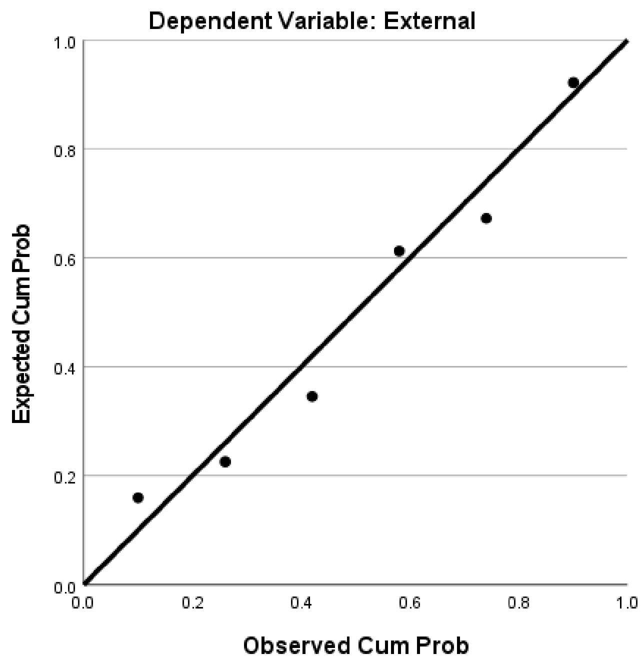
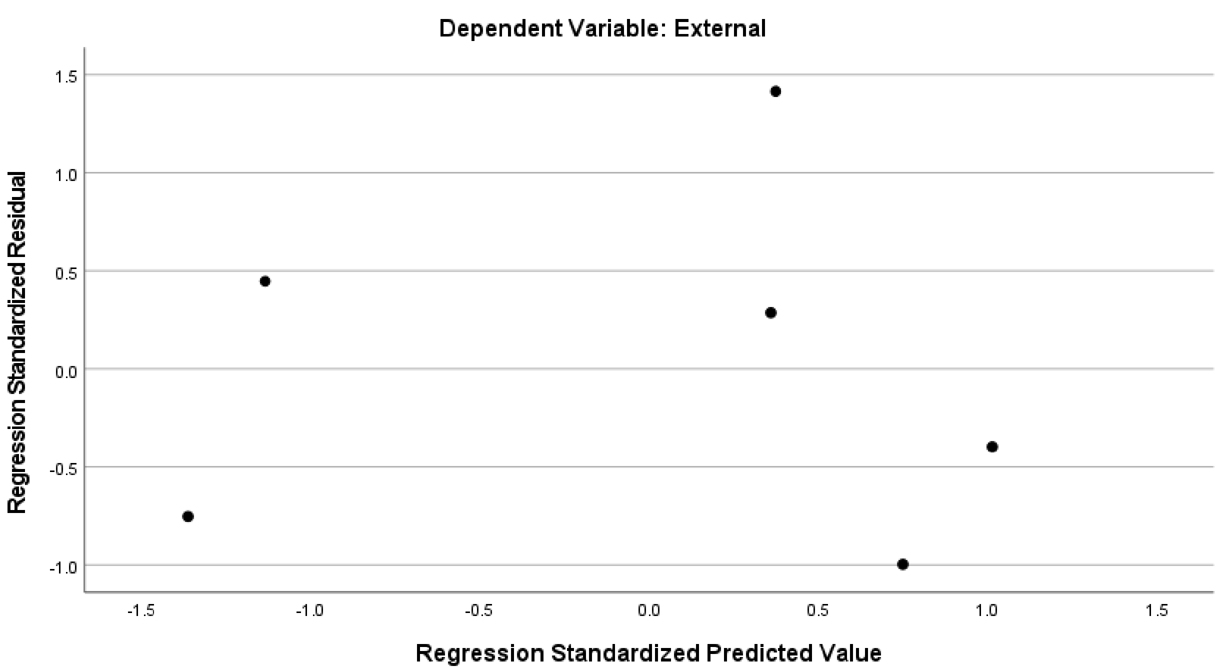


Figure 2.180

Scatterplot for Mathematics and Statistics



Non-Science and Engineering Fields

Table 2.46 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Non-Science and Engineering Fields R&D expenditures. Figure 2.181 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Non-Science and Engineering Fields reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.182. Standardized residuals were not normally distributed as shown in Figure 2.183. Scatterplots in Figure 2.184 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a statistically significant relationship between institutionally and externally funded R&D expenditures in the Non-Science and Engineering Fields, $F(1,4) = 37.49$, $p = .004$. A large effect size was noted with approximately 90.4% of the variances accounted for in the model, $R^2 = .904$.

Table 2.46

Descriptive Statistics for Non-Science and Engineering Fields (n = 6 and r = 0.95)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	10172
2015	1559	2774
2016	1415	17590
2017	2400	17468
2018	2380	17751
2019	2316	19018
2020	2645	-
M	2119.17	14128.83
SD	504.34	6399.10

Figure 2.181

Scatter Plot of External by Institutional for Non-Science and Engineering Fields

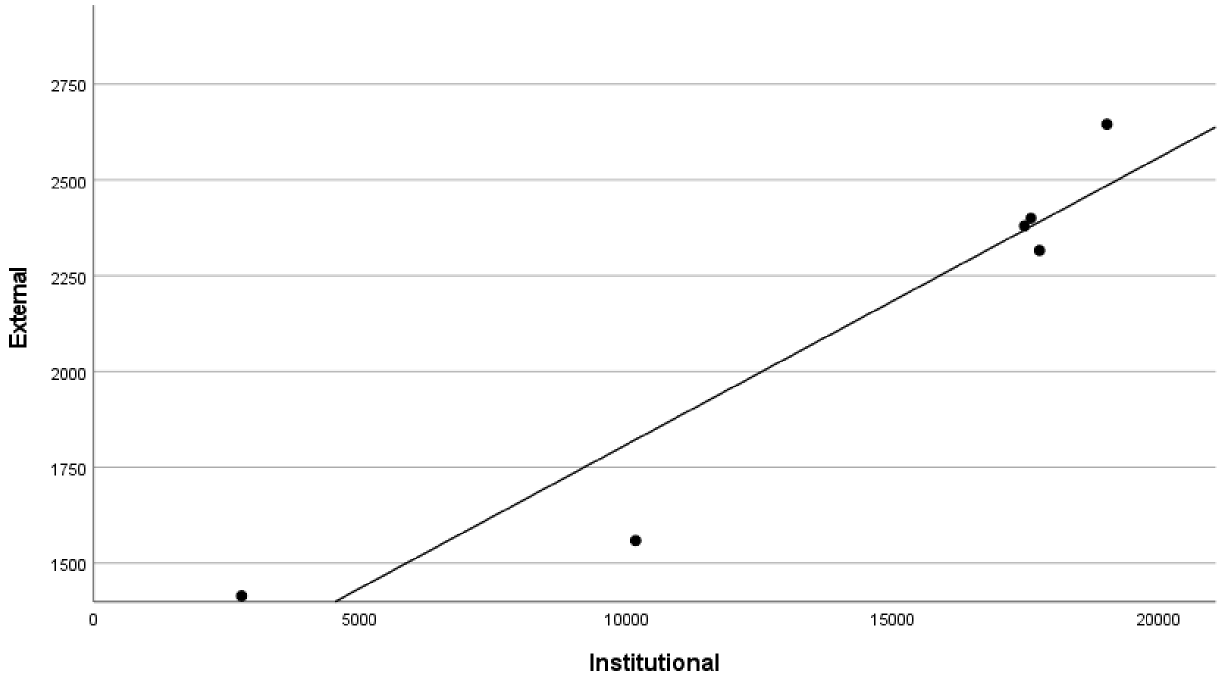


Figure 2.182

Normal Q-Q Plot of External for Non-Science and Engineering Fields

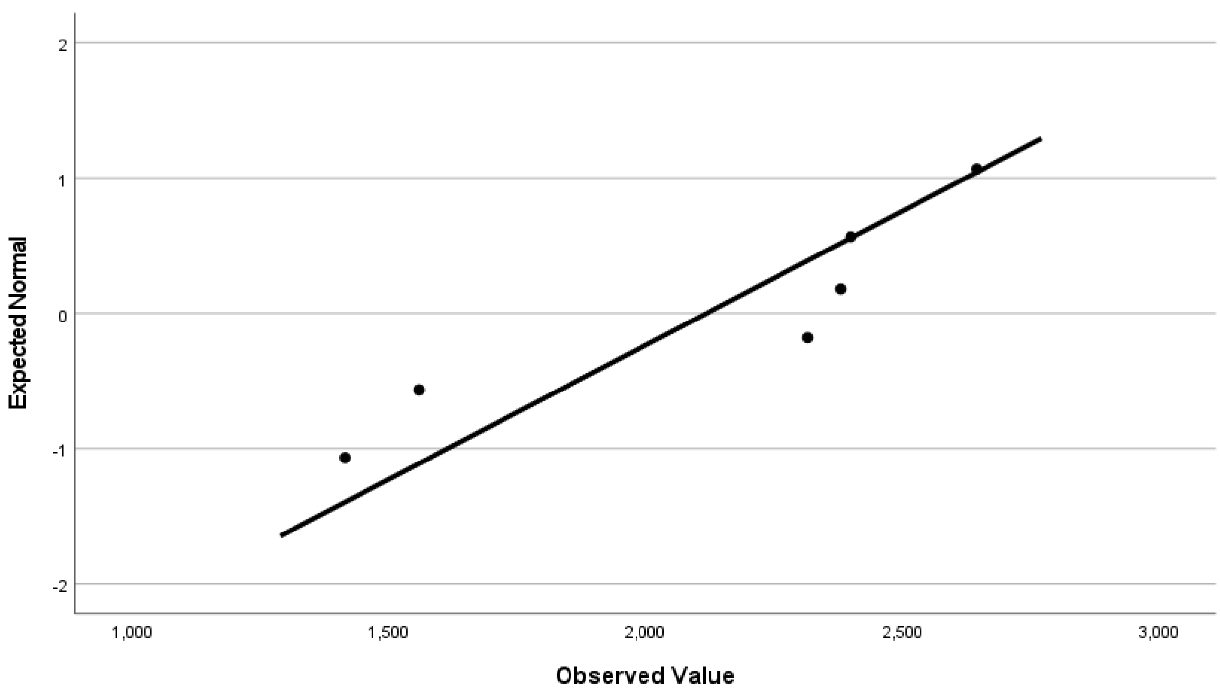


Figure 2.183

Normal P-P Plot of Regression Standardized Residual for Non-Science and Engineering Fields

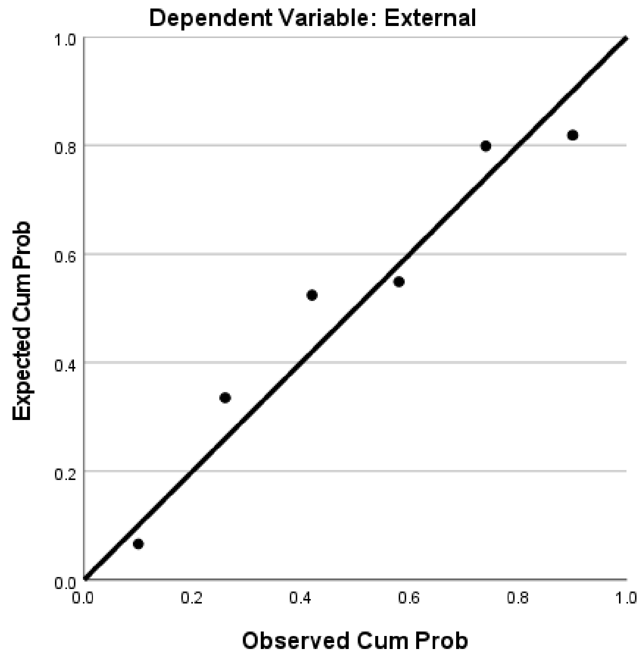
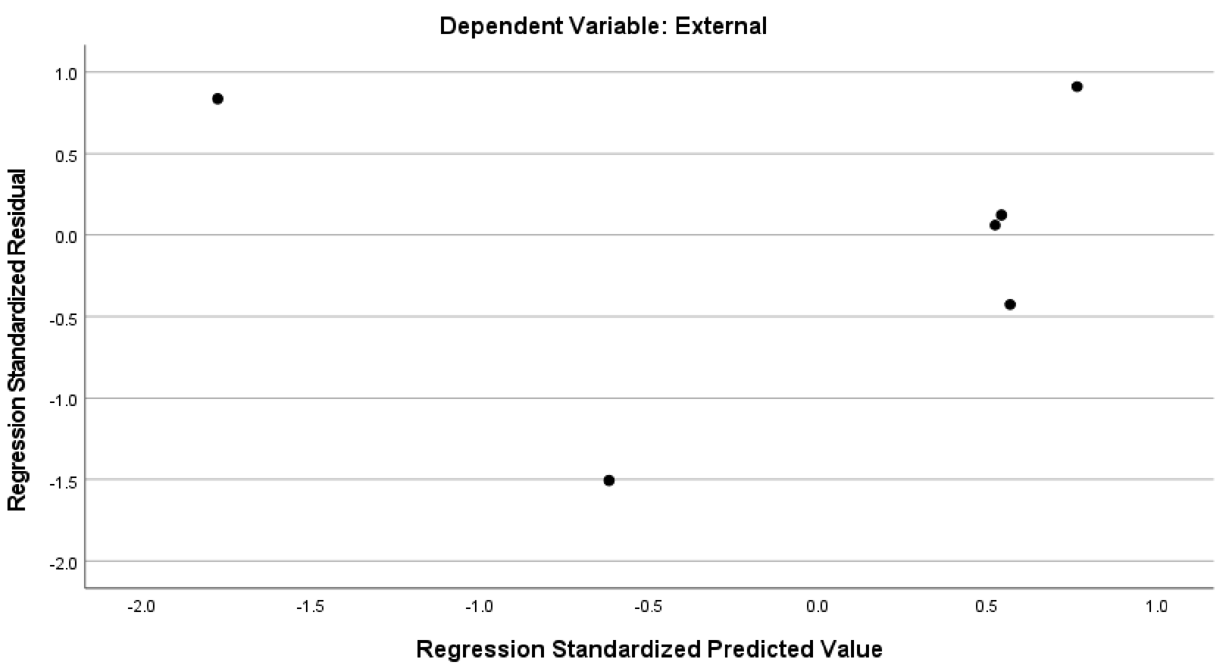


Figure 2.184

Scatterplot for Non-Science and Engineering Fields



Communication and Communications Technologies

Table 2.47 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Communication and Communications (C&C) Technologies R&D expenditures. Figure 2.185 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Communication and Communication Technologies subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.186. Standardized residuals were not normally distributed as shown in Figure 2.187. Scatterplots in Figure 2.188 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a statistically significant relationship between institutionally and externally funded R&D expenditures, $F(1,4) = 14.58$, $p = .019$. A large effect size was noted with approximately 78.5% of the variances accounted for in the model, $R^2 = .785$.

Table 2.47

Descriptive Statistics for C&C Technologies (n = 6 and r = 0.89)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	16
2015	0	90
2016	2	525
2017	15	631
2018	61	681
2019	68	727
2020	52	-
M	33.00	445.00
SD	30.80	311.86

Figure 2.185

Scatter Plot of External by Institutional for C&C Technologies

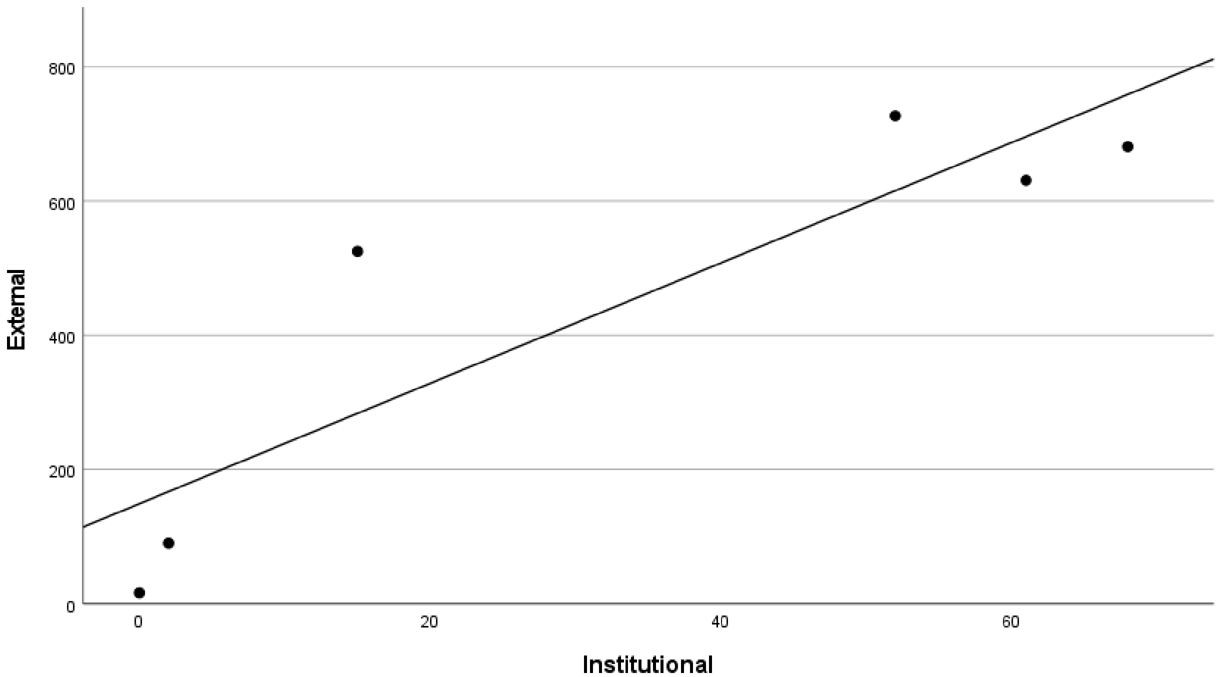


Figure 2.186

Normal Q-Q Plot of External for C&C Technologies

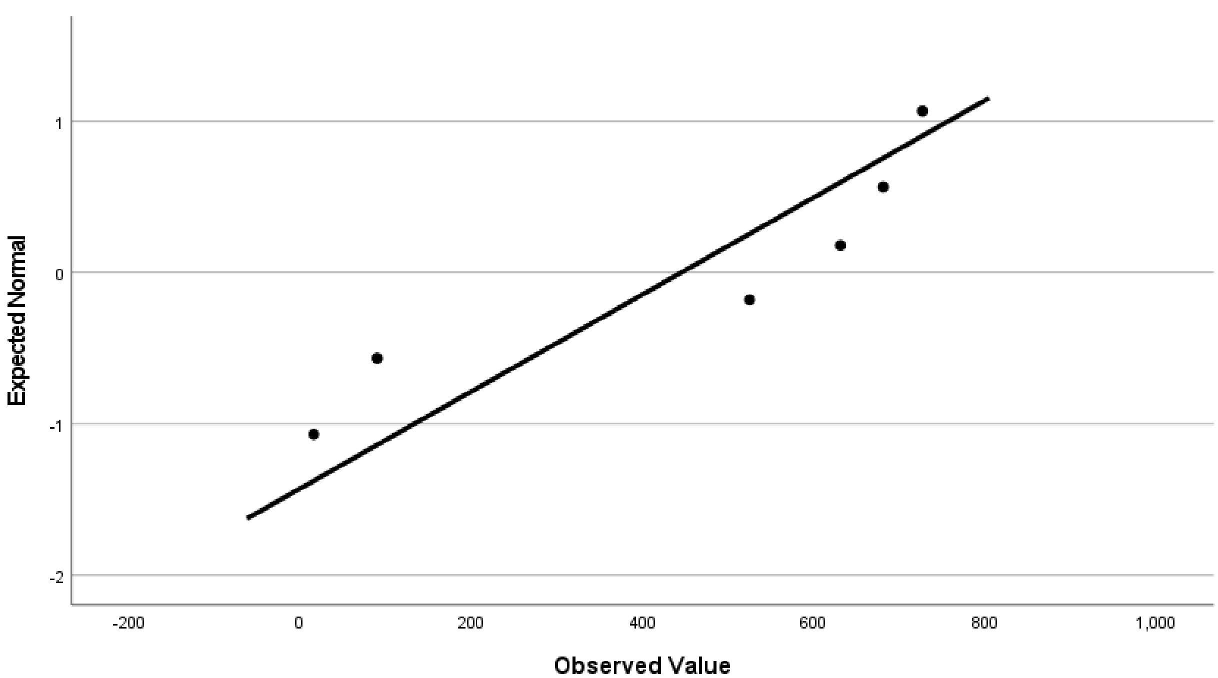


Figure 2.187

Normal P-P Plot of Regression Standardized Residual for C&C Technologies

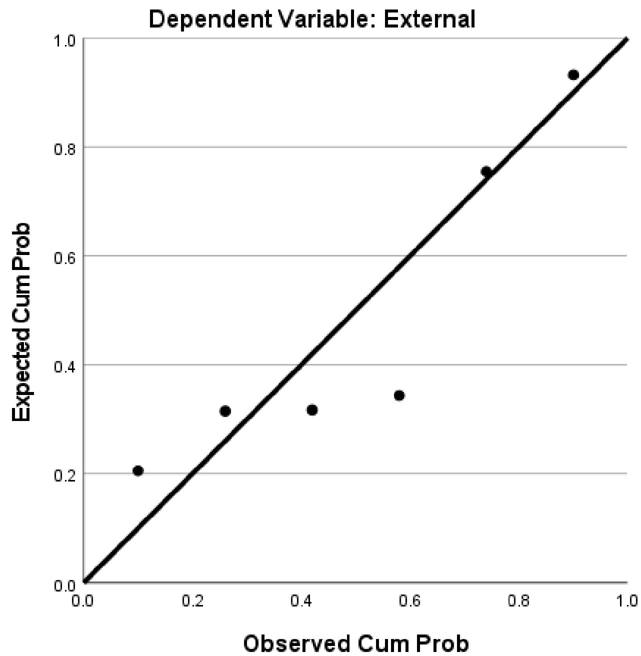
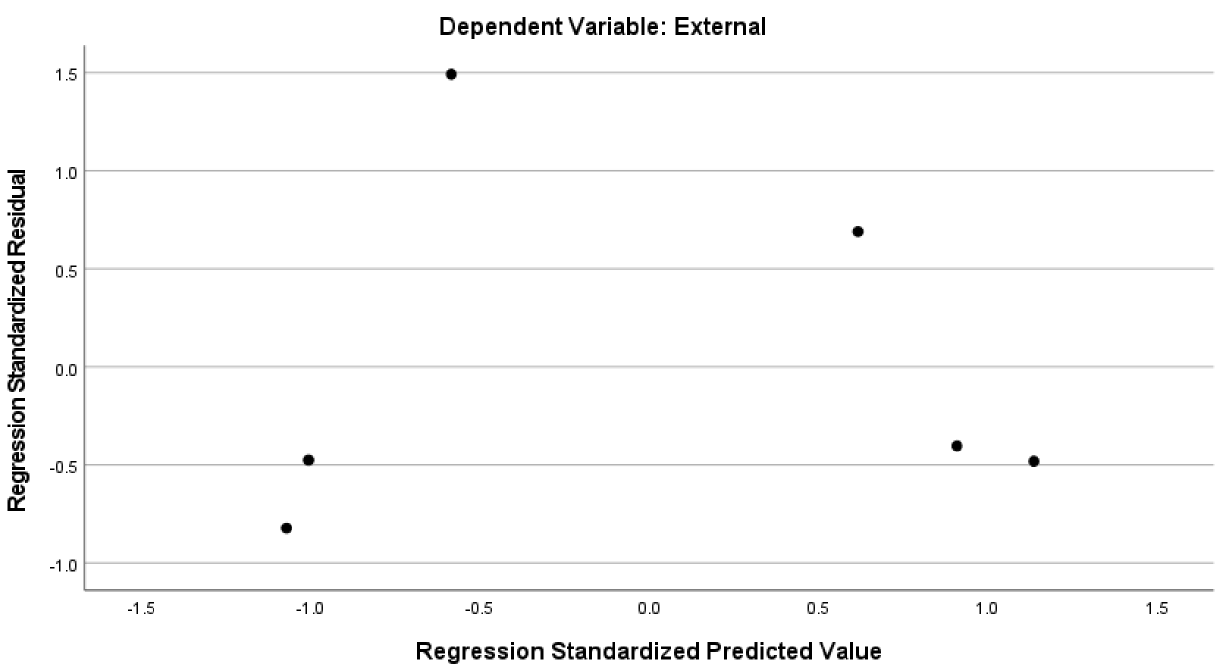


Figure 2.188

Scatterplot for C&C Technologies



Education

Table 2.48 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Education R&D expenditures. Figure 2.189 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Education subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.190. Standardized residuals were not normally distributed as shown in Figure 2.191. Scatterplots in Figure 2.192 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Education subfield, $F(1,4) = 2.29$, $p = .205$. A large effect size was noted with approximately 36.4% of the variances accounted for in the model, $R^2 = .364$.

Table 2.48

Descriptive Statistics for Education (n = 6 and r = 0.60)

	R&D Expenditures (Dollars in thousands)	
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	186
2015	218	273
2016	257	1305
2017	302	1444
2018	447	1631
2019	378	1508
2020	852	-
M	409.00	1057.83
SD	232.25	650.76

Figure 2.189

Scatter Plot of External by Institutional for Education

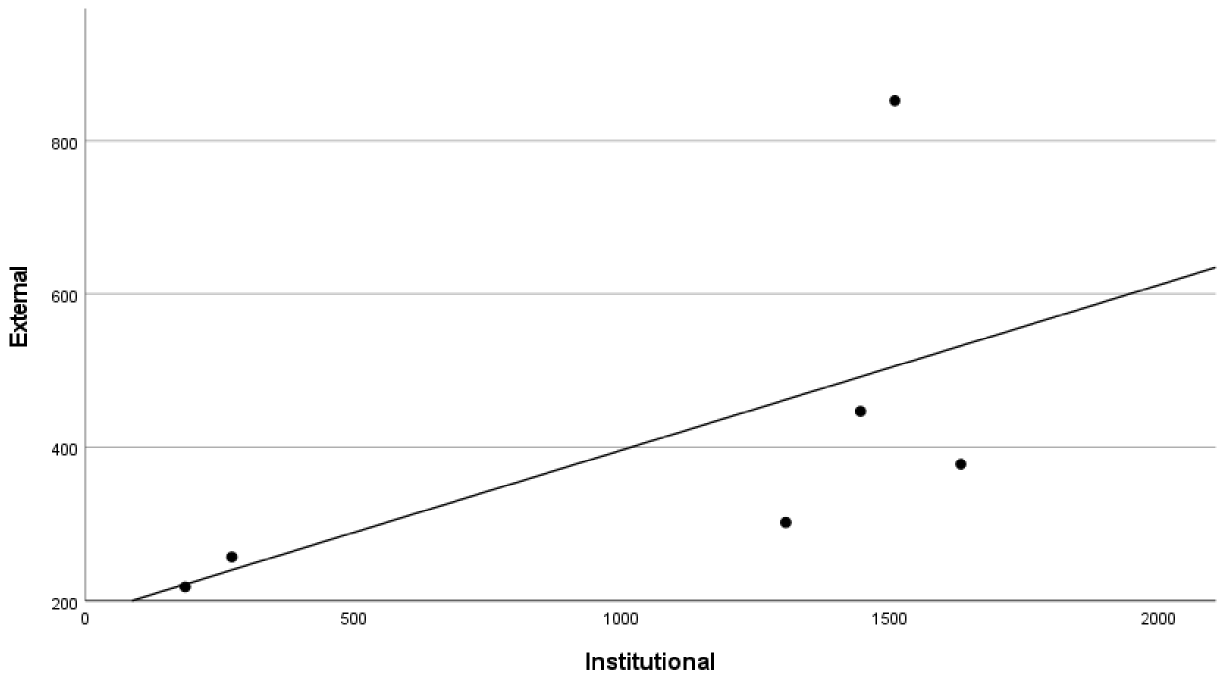


Figure 2.190

Normal Q-Q Plot of External for Education

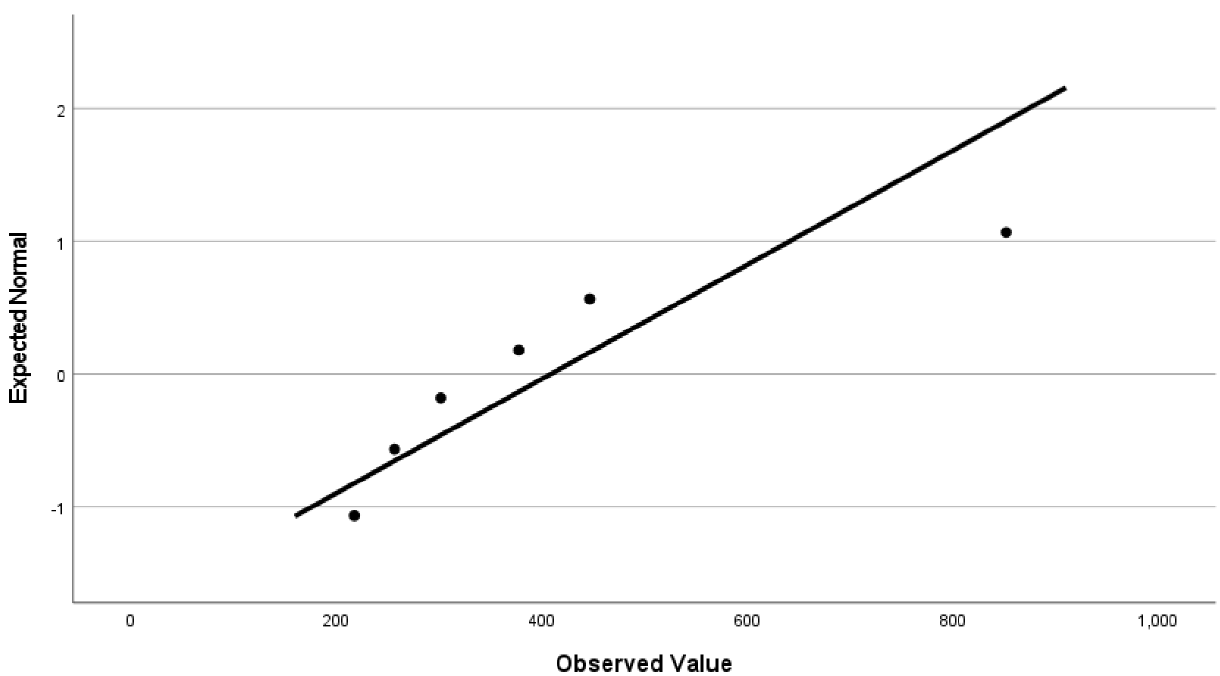


Figure 2.191

Normal P-P Plot of Regression Standardized Residual for Education

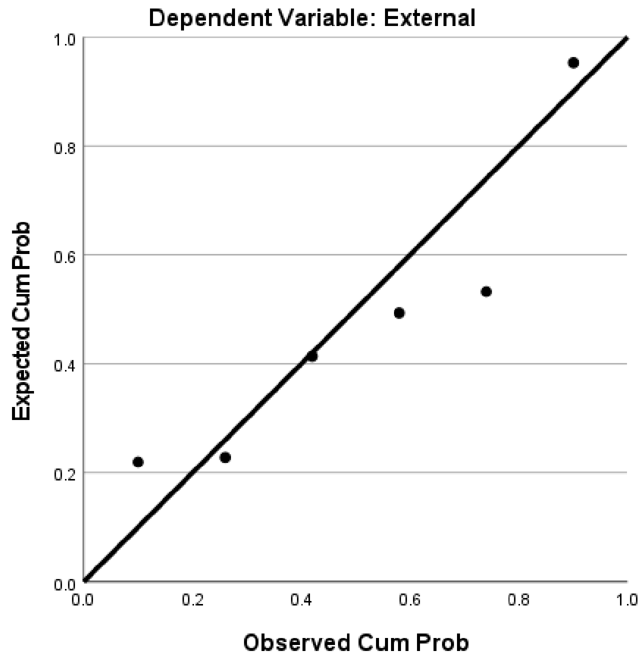
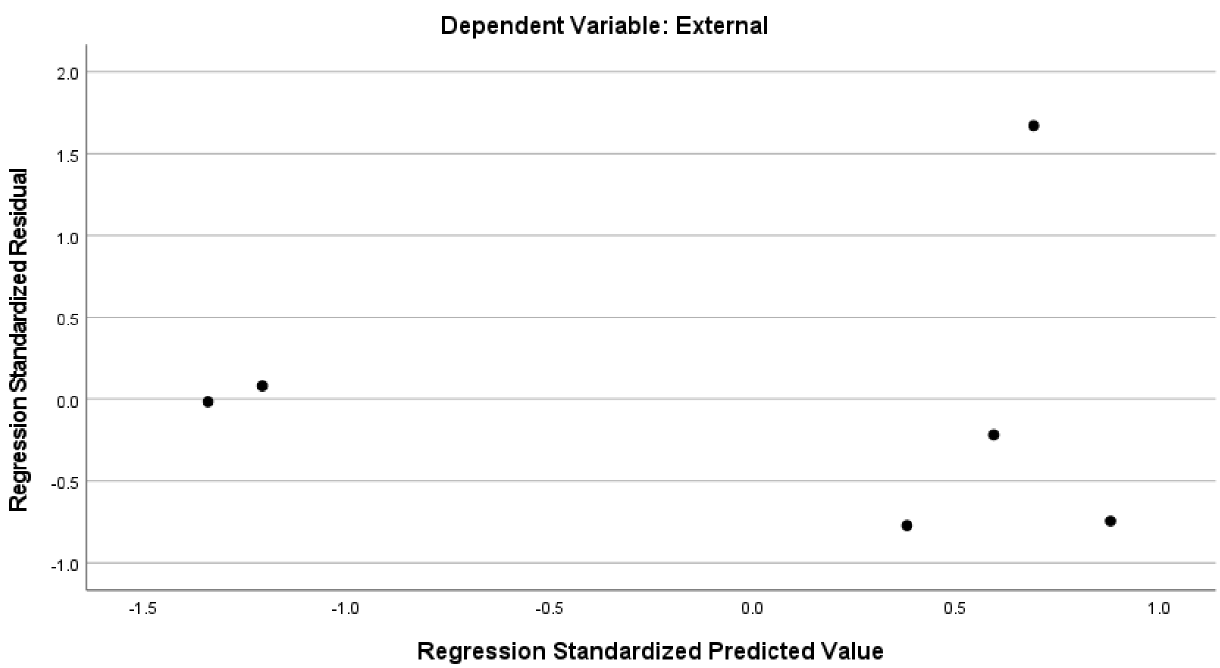


Figure 2.192

Scatterplot for Education



Humanities

Table 2.49 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Humanities R&D expenditures. Figure 2.193 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Humanities subfield reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.194, and standardized residuals were normally distributed as shown in Figure 2.195 as half of the values fall closely on the line. Scatterplots in Figure 2.196 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Humanities subfield, $F(1,4) = 2.48$, $p = .190$. A large effect size was noted with approximately 38.3% of the variances accounted for in the model, $R^2 = .383$.

Table 2.49

Descriptive Statistics for Humanities (n = 6 and r = 0.62)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	1290
2015	17	1003
2016	40	5217
2017	88	5261
2018	125	4746
2019	171	5582
2020	50	-
M	81.83	3849.83
SD	58.00	2112.88

Figure 2.193

Scatter Plot of External by Institutional for Humanities

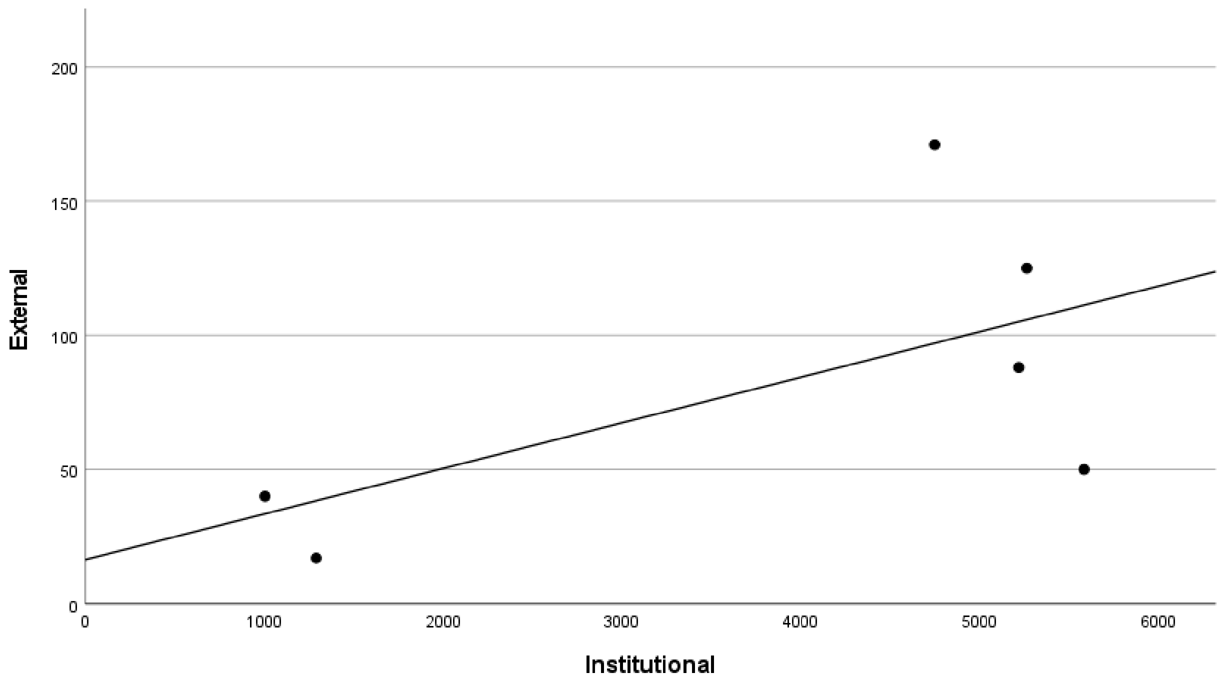


Figure 2.194

Normal Q-Q Plot of External for Humanities

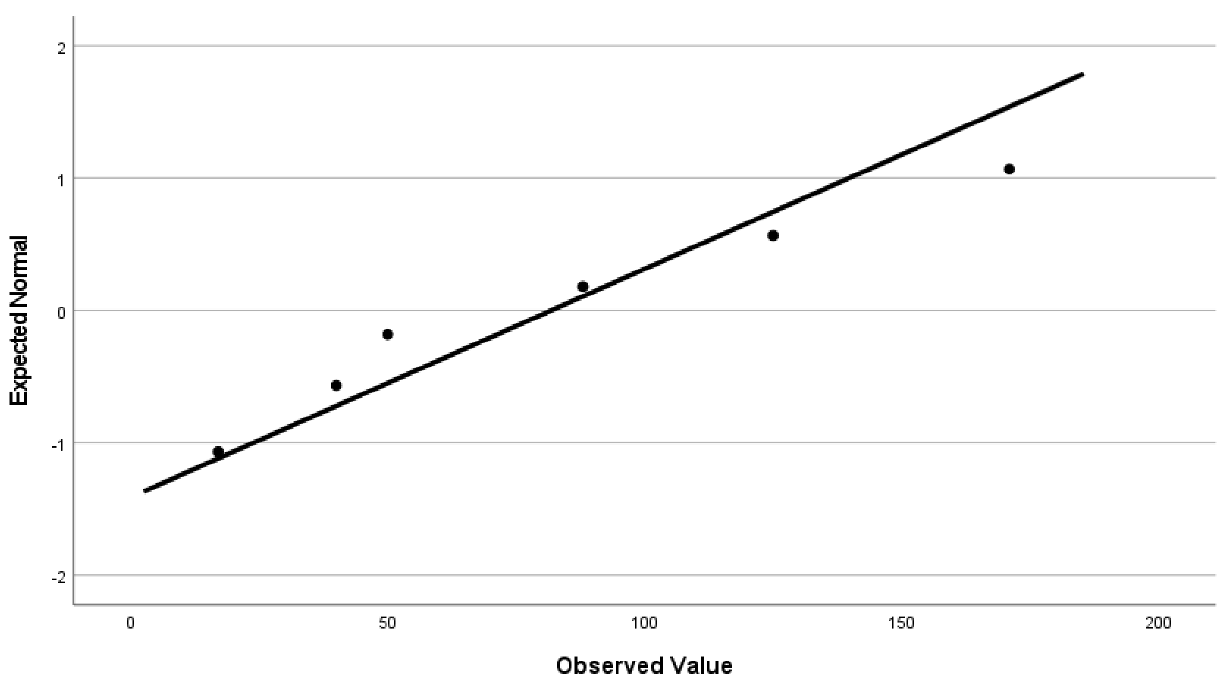


Figure 2.195

Normal P-P Plot of Regression Standardized Residual for Humanities

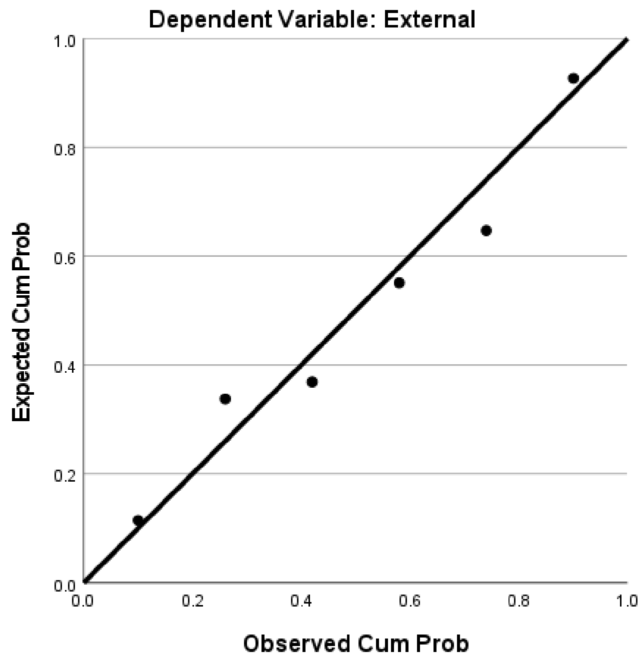
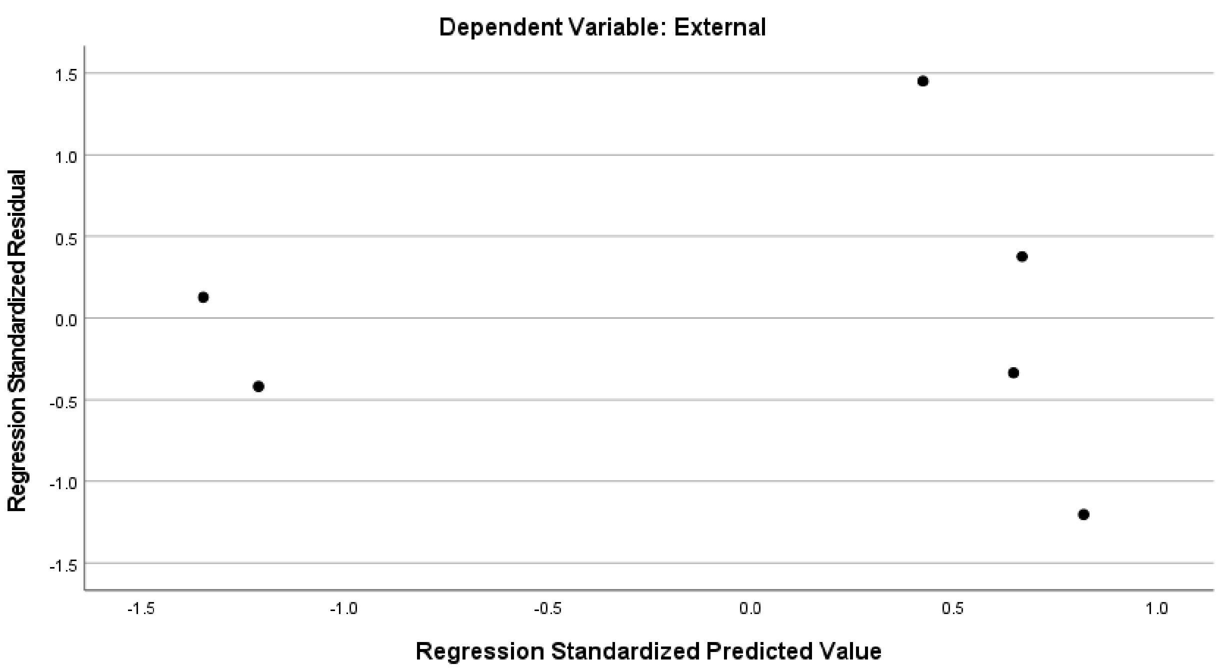


Figure 2.196

Scatterplot for Humanities



Law

Table 2.50 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Law R&D expenditures. Figure 2.197 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Law subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.198. Standardized residuals were not normally distributed as shown in Figure 2.199. Scatterplots in Figure 2.200 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a statistically significant relationship between institutionally and externally funded R&D expenditures in the Law subfield, $F(1,4) = 86.53$, $p = < .001$. A large effect size was noted with approximately 95.6% of the variances accounted for in the model, $R^2 = .956$.

Table 2.50

Descriptive Statistics for Law (n = 6 and r = 0.98)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	379
2015	1192	393
2016	1021	2781
2017	1913	1842
2018	1707	1887
2019	1678	1749
2020	1645	-
M	1526.00	1505.17
SD	342.46	943.57

Figure 2.197

Scatter Plot of External by Institutional for Law

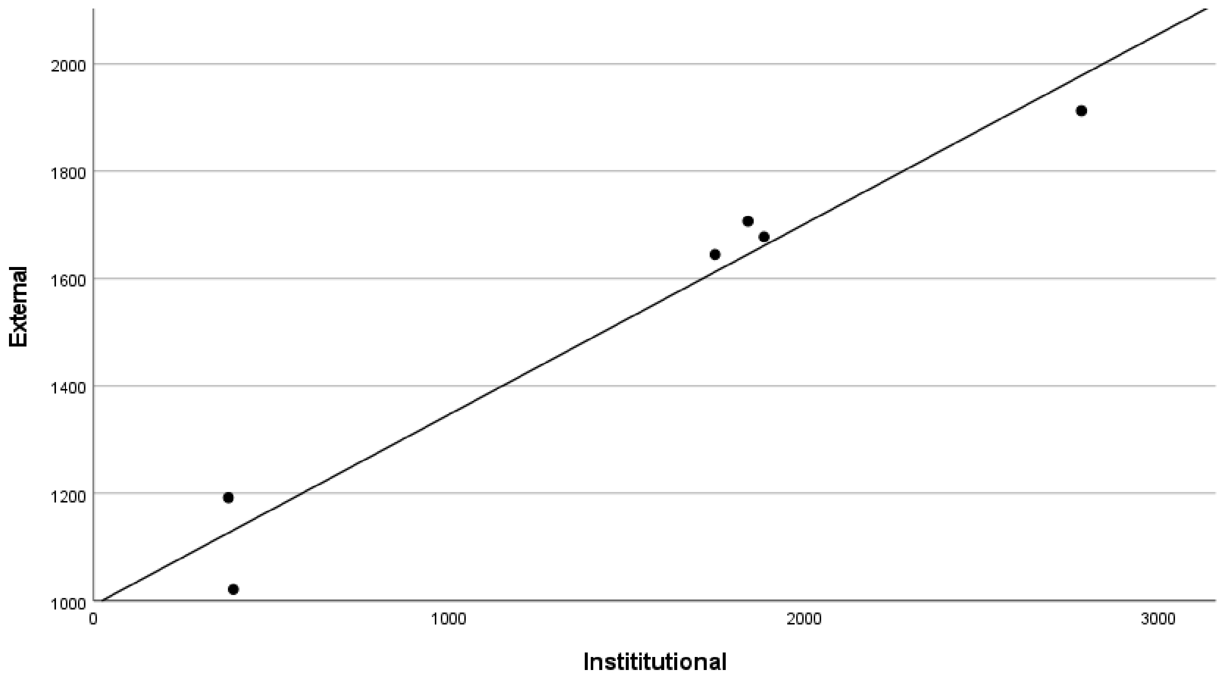


Figure 2.198

Normal Q-Q Plot of External for Law

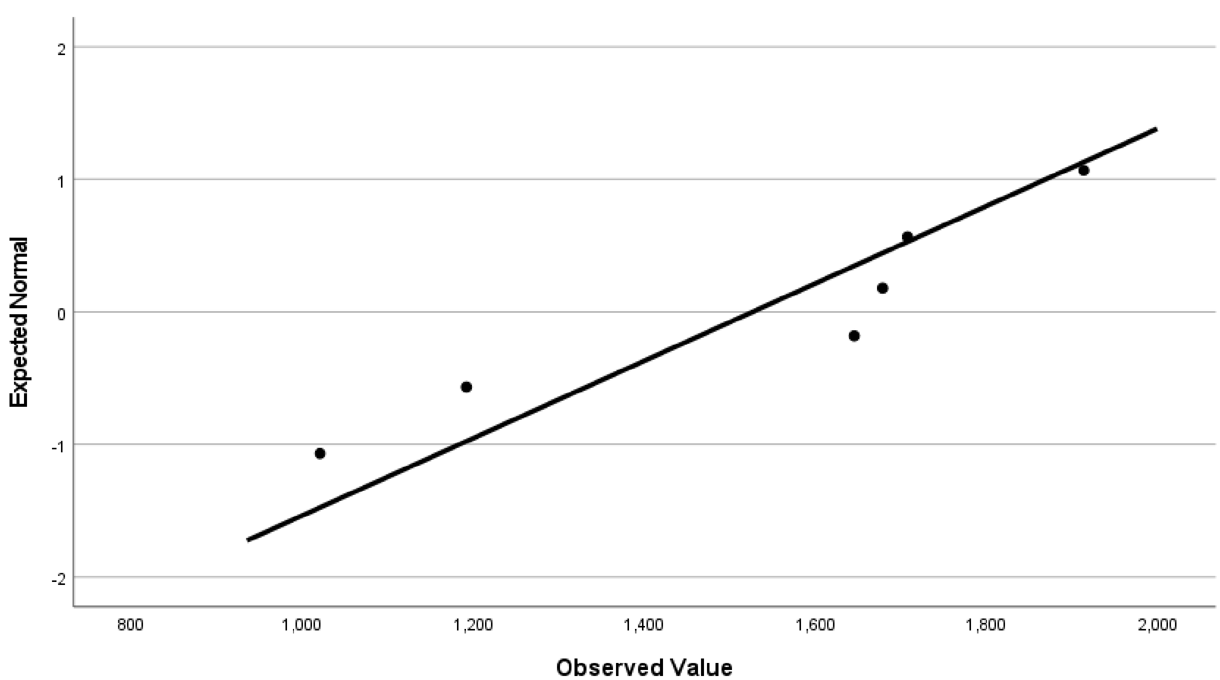


Figure 2.199

Normal P-P Plot of Regression Standardized Residual for Law

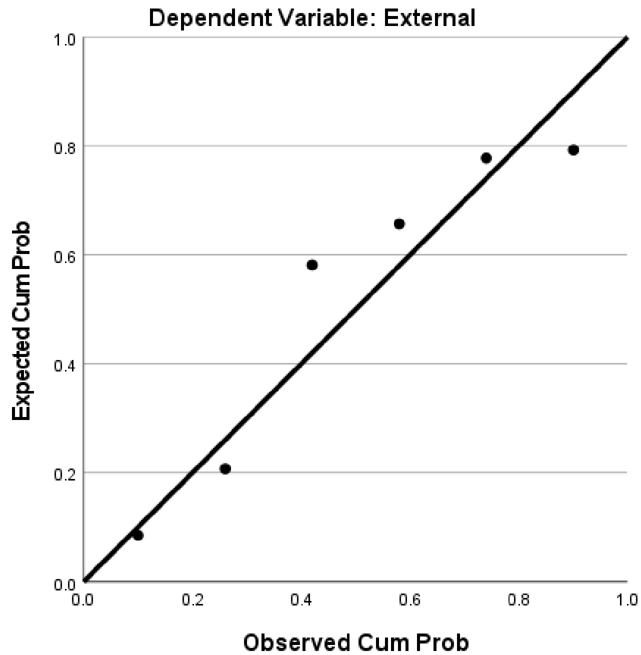
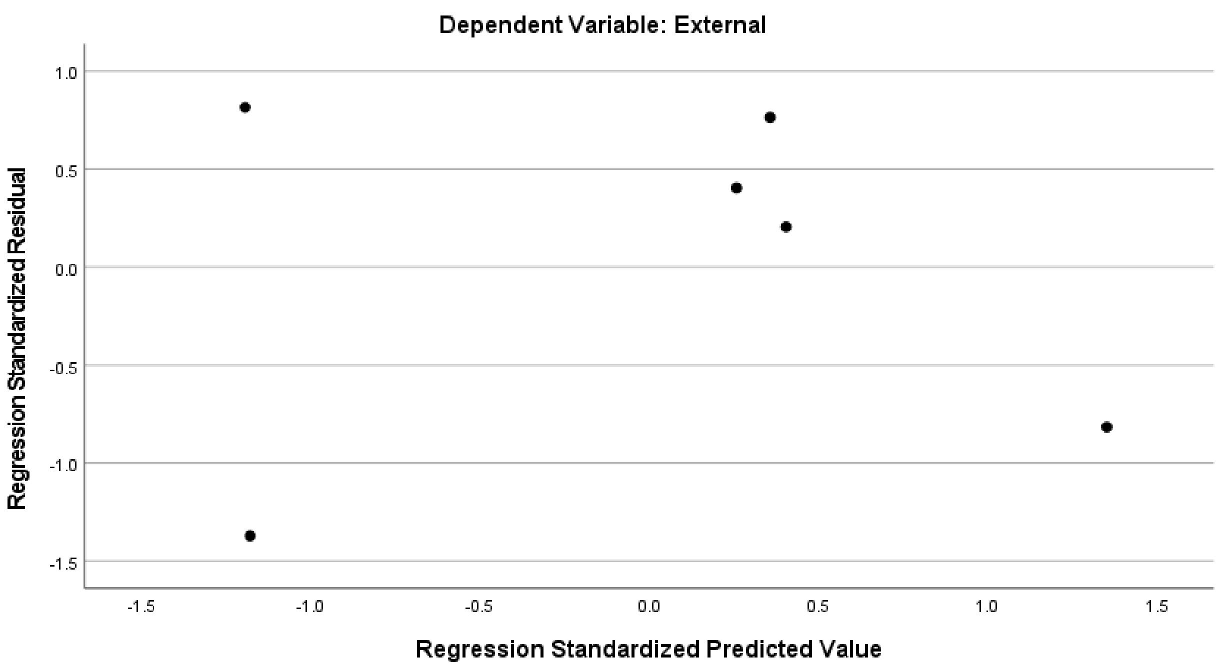


Figure 2.200

Scatterplot for Law



Social Work

Table 2.51 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Social Work R&D expenditures. Figure 2.201 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Social Work subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.202. Standardized residuals were somewhat normally distributed as shown in Figure 2.203. Scatterplots in Figure 2.204 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Social Work subfield, $F(1,4) = .11$, $p = .755$. A small effect size was noted with approximately 2.7% of the variances accounted for in the model, $R^2 = .027$.

Table 2.51

Descriptive Statistics for Social Work (n = 6 and r = 0.17)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	4
2015	5	6
2016	6	290
2017	9	503
2018	10	622
2019	0	425
2020	38	-
M	11.33	308.33
SD	13.53	258.56

Figure 2.201

Scatter Plot of External by Institutional for Social Work

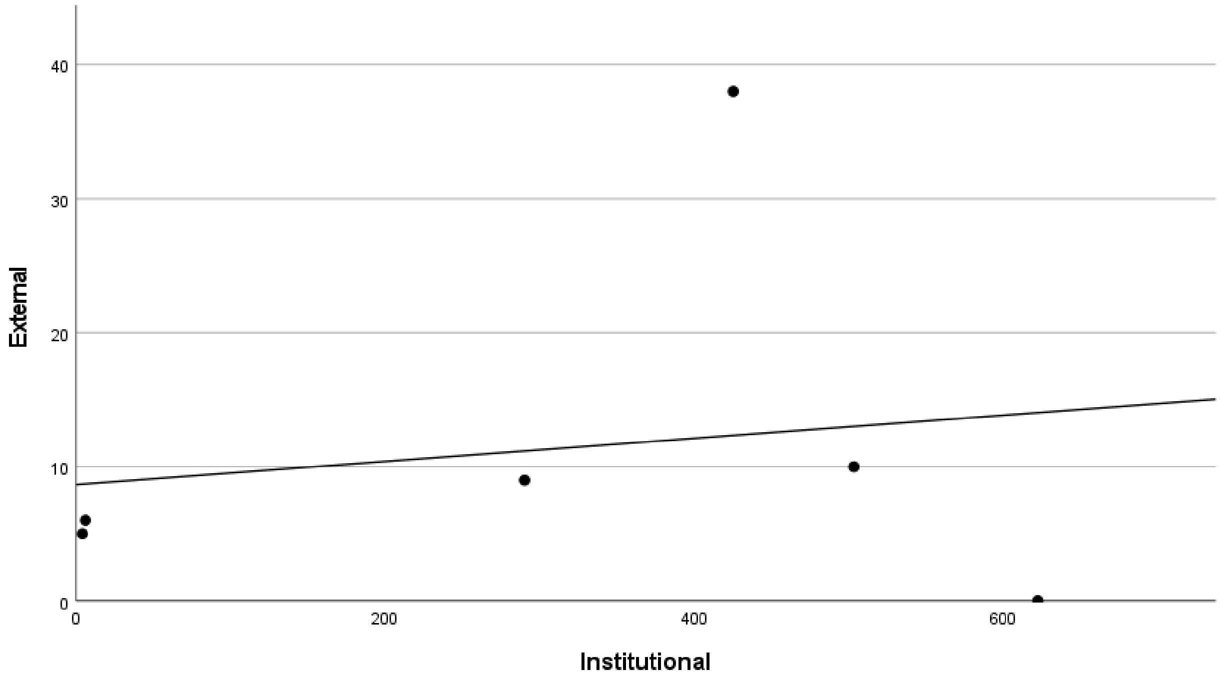


Figure 2.202

Normal Q-Q Plot of External for Social Work

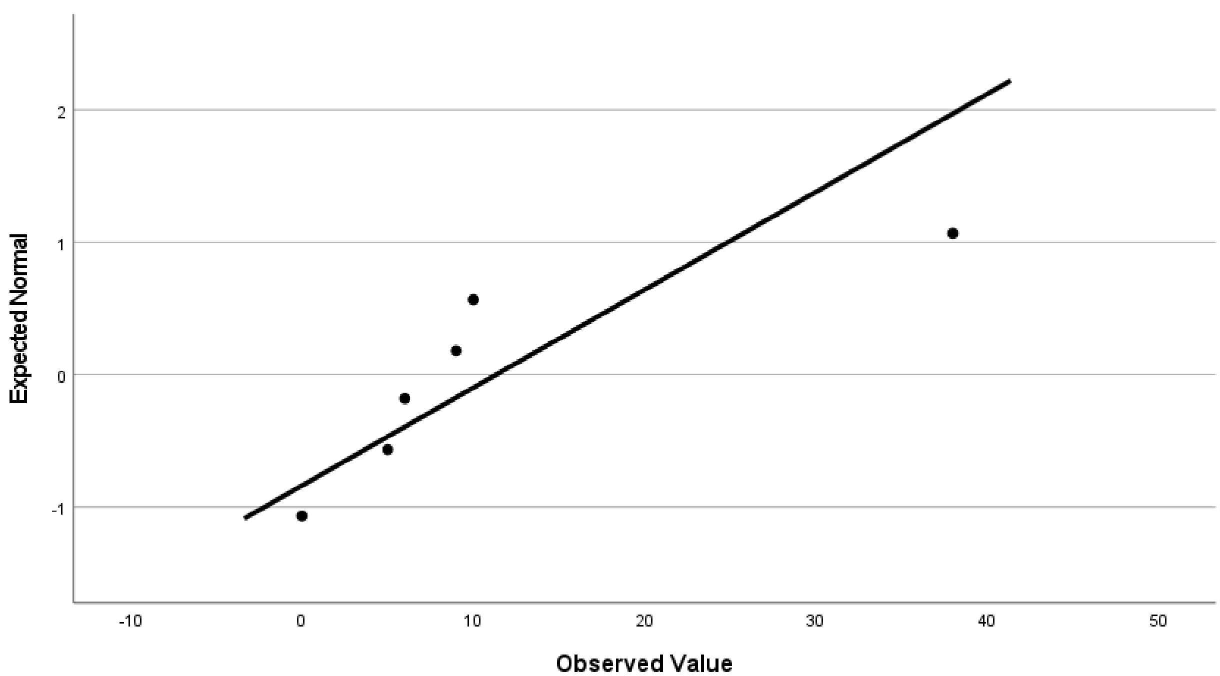


Figure 2.203

Normal P-P Plot of Regression Standardized Residual for Social Work

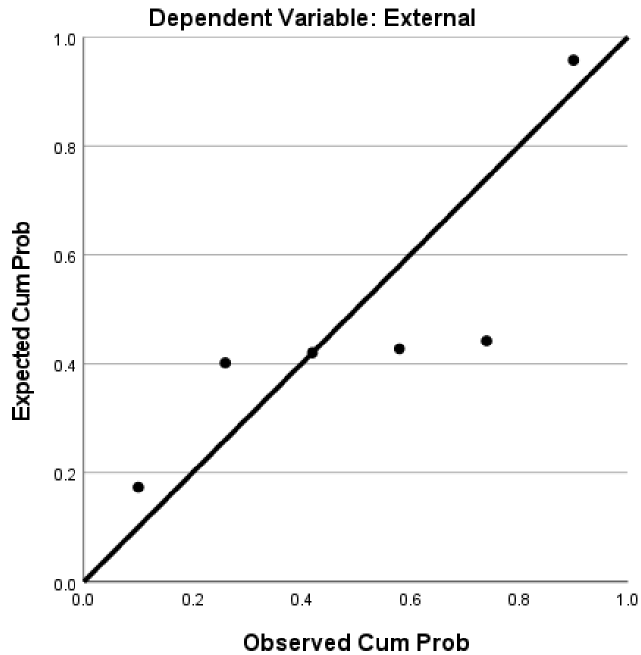
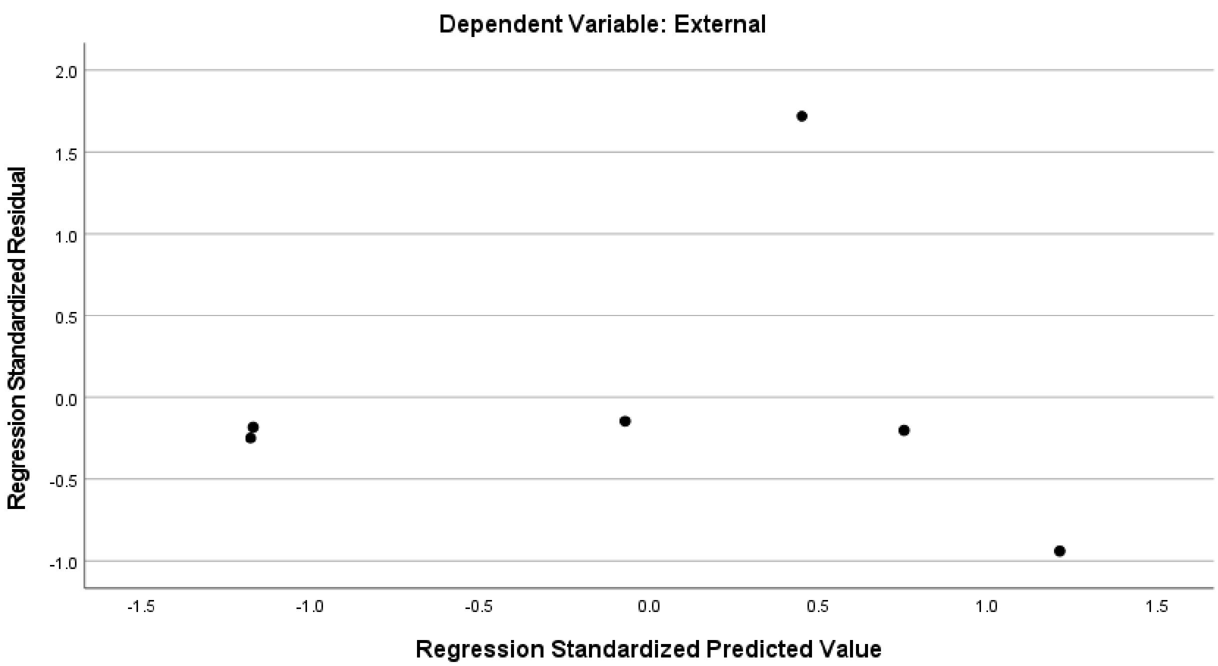


Figure 2.204

Scatterplot for Social Work



Other Non-Science and Engineering

The NSF HERD Survey (n.d.) categorizes Other Non-Science and Engineering fields that cannot be specifically identified within the previously listed subfields as Other Non-Science and Engineering. Table 2.52 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Non-Science and Engineering R&D expenditures. Figure 2.205 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Other Non-Science and Engineering subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.206. Standardized residuals were not normally distributed as shown in Figure 2.207. Scatterplots in Figure 2.208 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Non-Science and Engineering fields, $F(1,4) = 7.46$, $p = .052$. A large effect size was noted with approximately 65.1% of the variances accounted for in the model, $R^2 = .651$.

Table 2.52

Descriptive Statistics for Other Non-Science and Engineering (n = 6 and r = 0.81)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	7462
2015	64	259
2016	30	1820
2017	25	1949
2018	23	1893
2019	21	2194
2020	8	-
M	28.50	2596.17
SD	18.88	2482.58

Figure 2.205

Scatter Plot of External by Institutional for Other Non-Science and Engineering

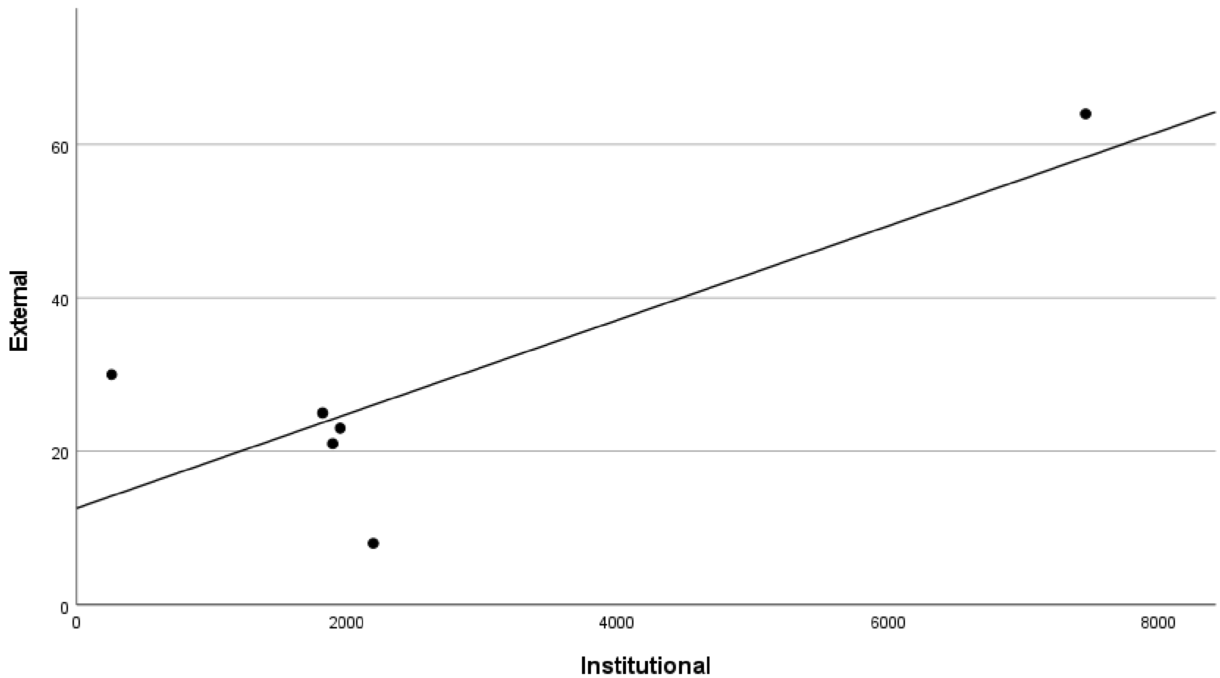


Figure 2.206

Normal Q-Q Plot of External for Other Non-Science and Engineering

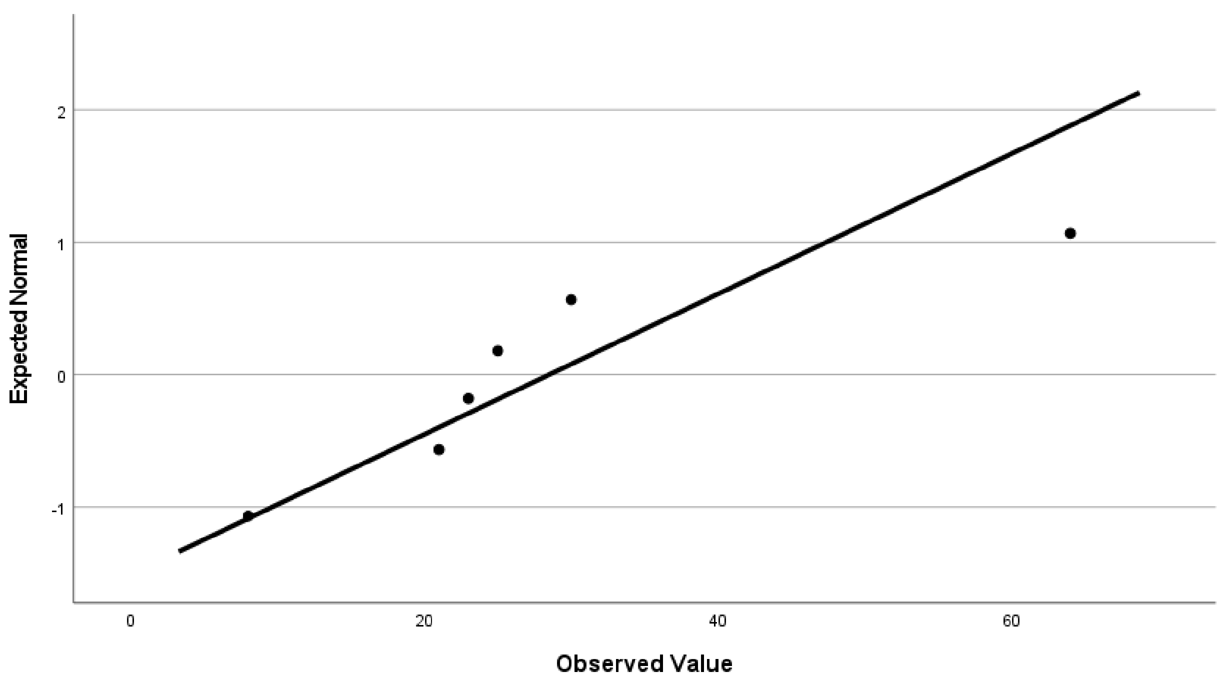


Figure 2.207

Normal P-P Plot of Regression Standardized Residual for Other Non-Science and Engineering

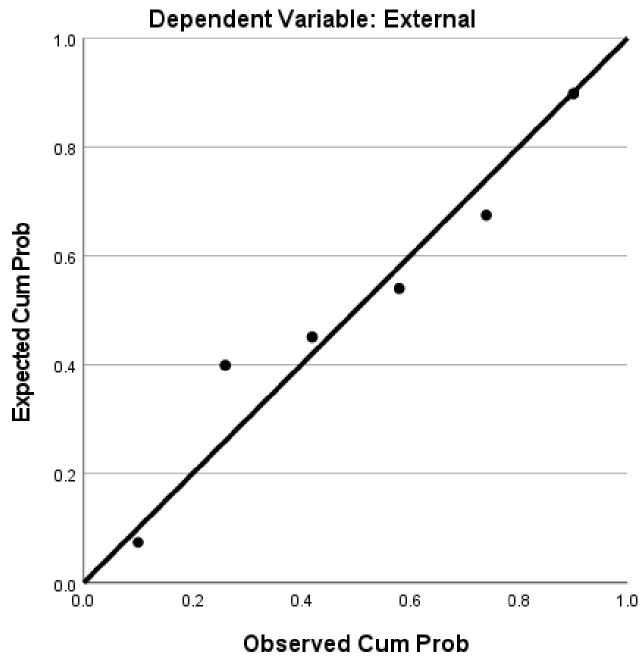
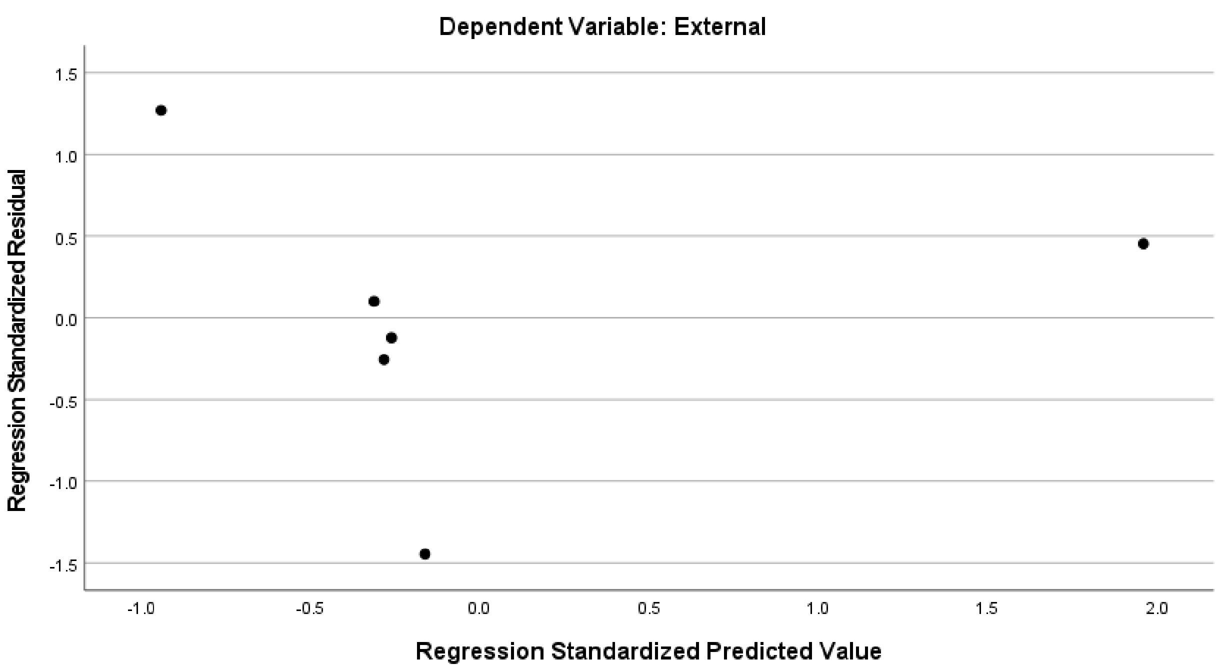


Figure 2.208

Scatterplot for Other Non-Science and Engineering



Physical Sciences

Table 2.53 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Physical Sciences R&D expenditures. Figure 2.209 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Physical Sciences field reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.210, and standardized residuals were somewhat normally distributed as shown in Figure 2.211 as half of the values fall closely on the line. Scatterplots in Figure 2.212 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Physical Sciences field, $F(1,4) = .08$, $p = .798$. A small effect size was noted with approximately 1.8% of the variances accounted for in the model, $R^2 = .018$.

Table 2.53

Descriptive Statistics for Physical Sciences (n = 6 and r = 0.14)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	2972
2015	6235	2798
2016	8142	4506
2017	8612	4994
2018	7239	3712
2019	9974	4643
2020	8208	-
M	8068.33	3937.50
SD	1264.99	918.54

Figure 2.209

Scatter Plot of External by Institutional for Physical Sciences

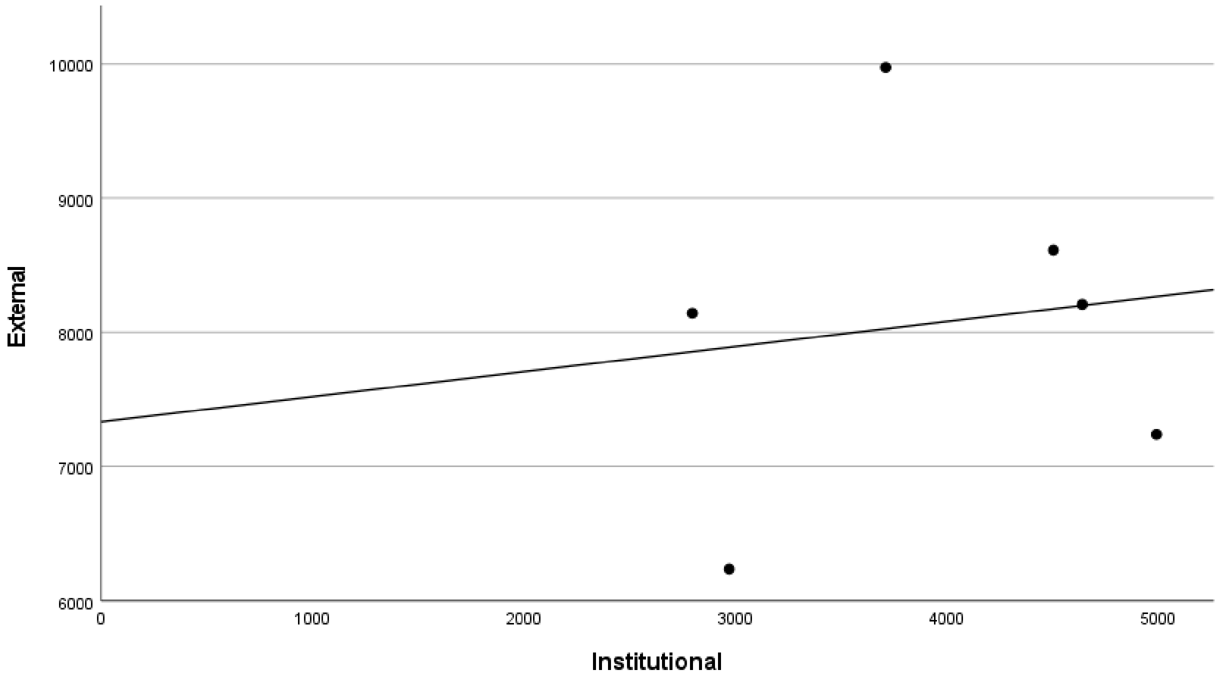


Figure 2.210

Normal Q-Q Plot of External for Physical Sciences

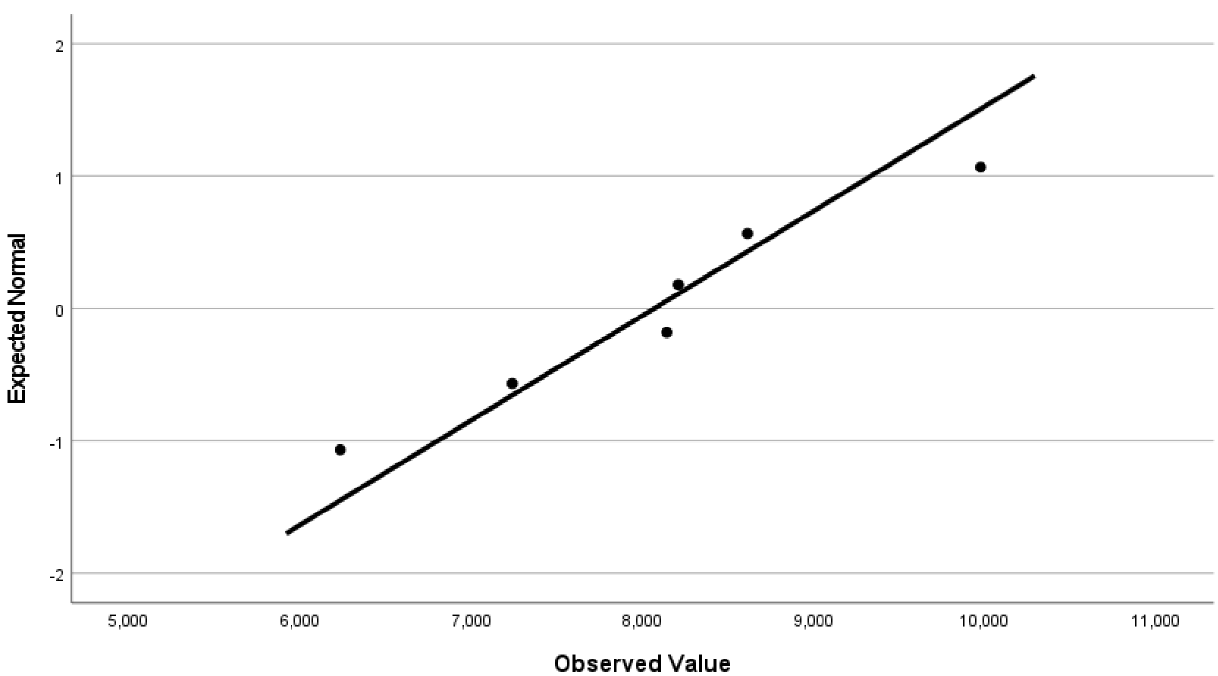


Figure 2.211

Normal P-P Plot of Regression Standardized Residual for Physical Sciences

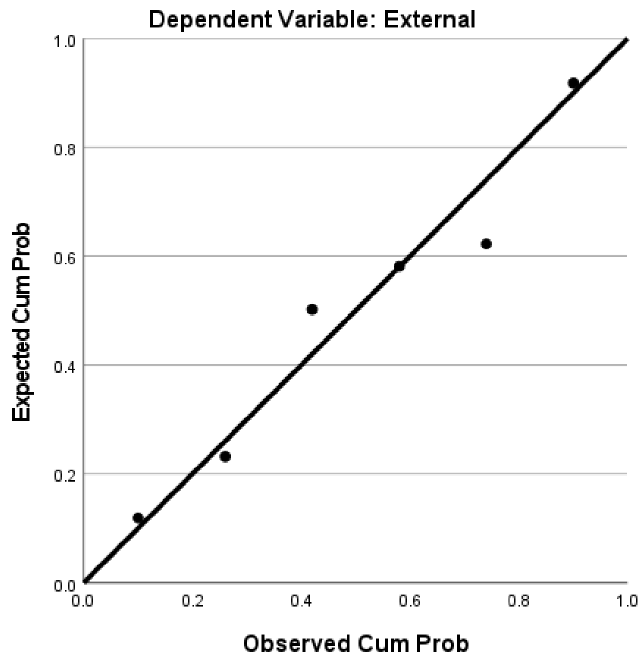
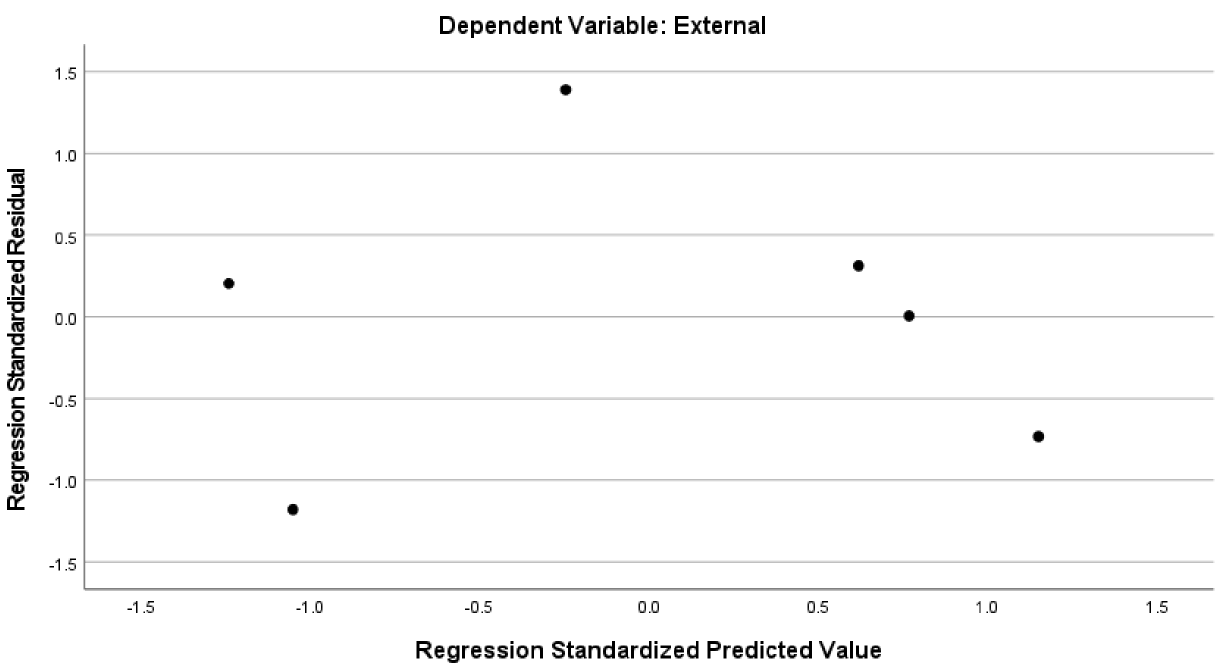


Figure 2.212

Scatterplot for Physical Sciences



Chemistry

Table 2.54 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Chemistry R&D expenditures. Figure 2.213 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Chemistry subfield reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.214 as half of the values fall on the line. Standardized residuals were somewhat normally distributed as shown in Figure 2.215. Scatterplots in Figure 2.216 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Chemistry subfield, $F(1,4) = .396$, $p = .563$. A small effect size was noted with approximately 9.0% of the variances accounted for in the model, $R^2 = .090$.

Table 2.54

Descriptive Statistics for Chemistry (n = 6 and r = 0.30)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	445
2015	1438	553
2016	1861	1716
2017	2397	2413
2018	2178	1421
2019	3939	2317
2020	2261	-
M	2345.67	1477.50
SD	852.69	843.89

Figure 2.213

Scatter Plot of External by Institutional for Chemistry

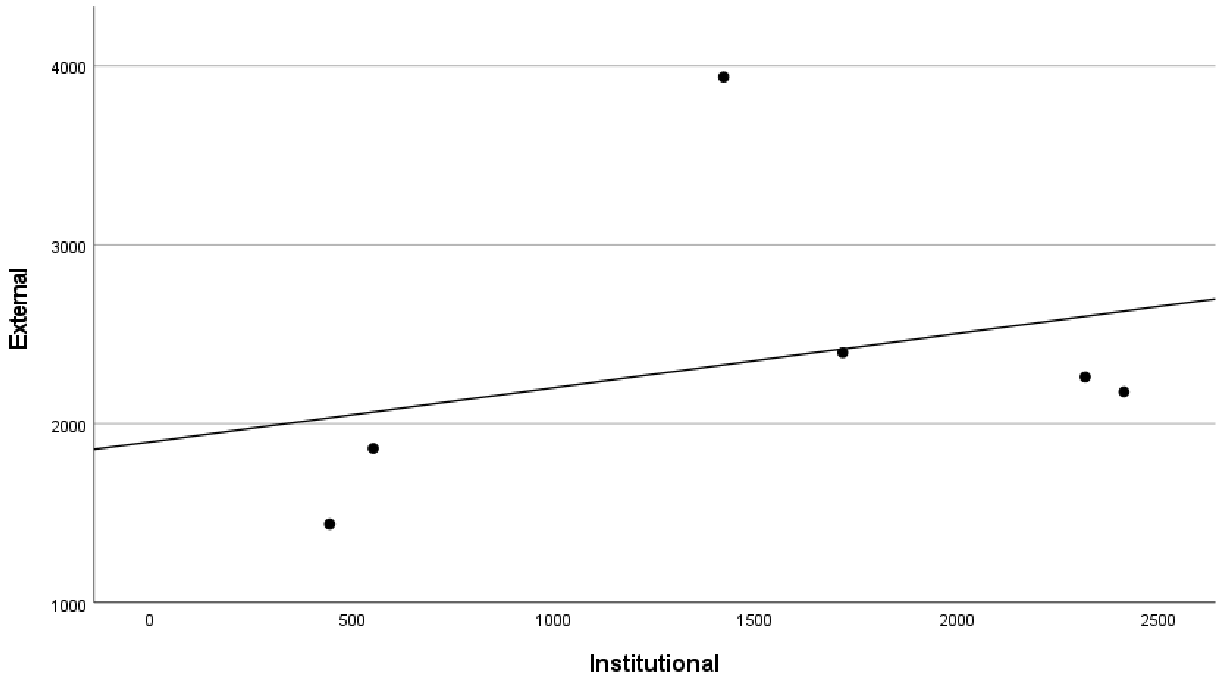


Figure 2.214

Normal Q-Q Plot of External for Chemistry

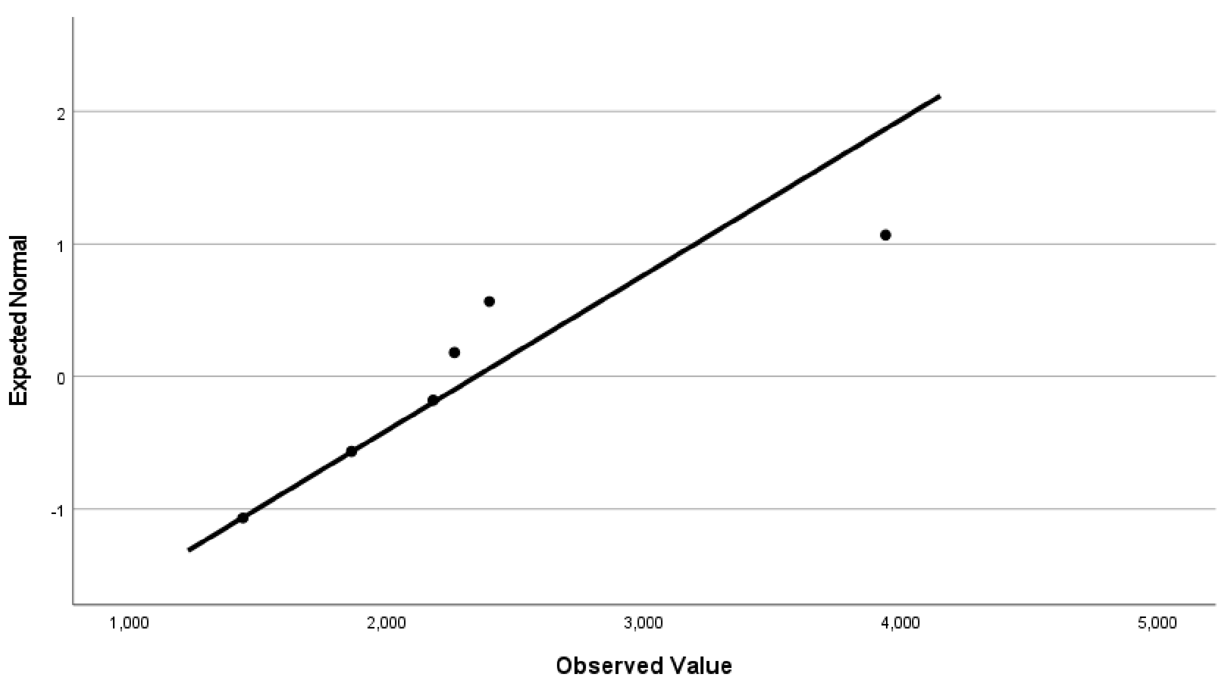


Figure 2.215

Normal P-P Plot of Regression Standardized Residual for Chemistry

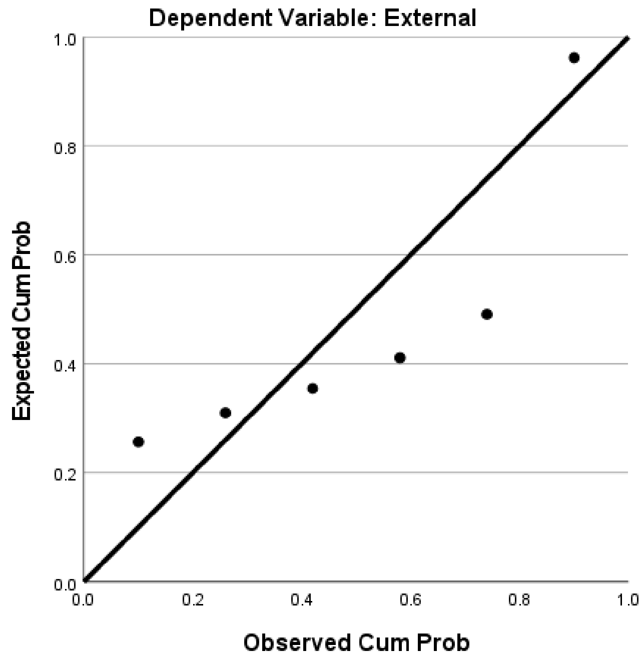
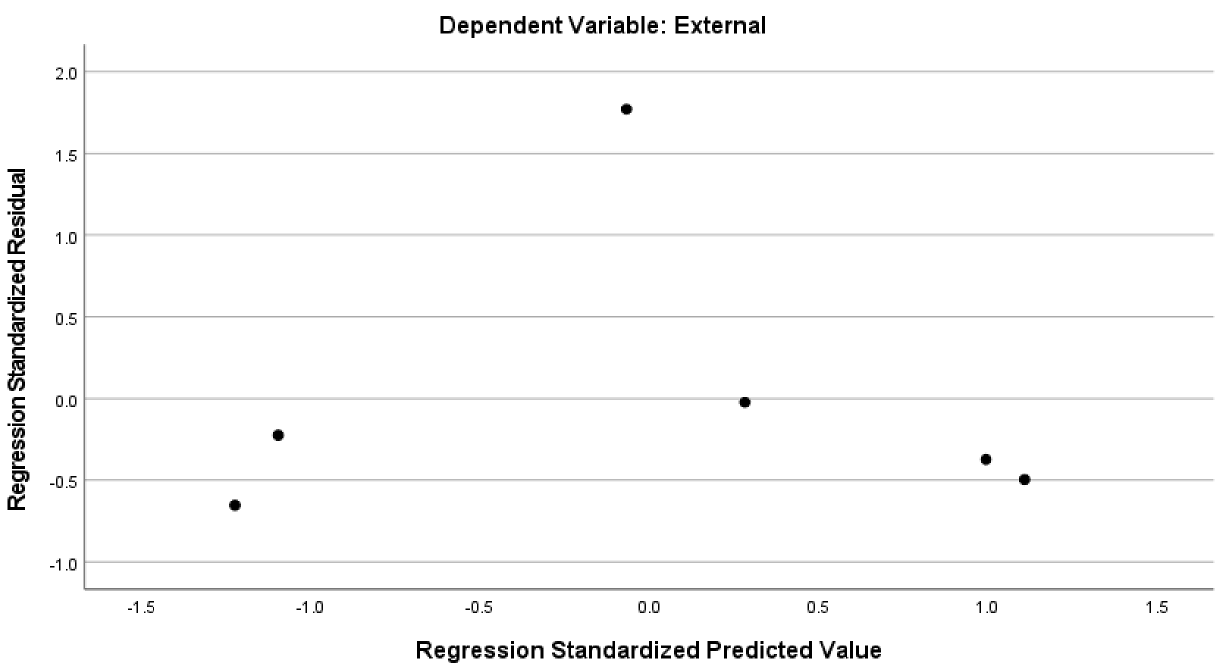


Figure 2.216

Scatterplot for Chemistry



Physics

Table 2.55 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Physics R&D expenditures. Figure 2.217 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Physics subfield reflecting a negative correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.218. Standardized residuals were somewhat normally distributed as shown in Figure 2.219 as more than half of the values fall closely on the line. Scatterplots in Figure 2.220 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Physics subfield, $F(1,4) = .33$, $p = .598$. A small effect size was noted with approximately 7.6% of the variances accounted for in the model, $R^2 = .076$.

Table 2.55

Descriptive Statistics for Physics (n = 6 and r = -0.28)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	2527
2015	4797	2245
2016	6281	2790
2017	6215	2581
2018	5058	2291
2019	6035	2326
2020	5947	-
M	5722.17	2460.00
SD	632.56	210.13

Figure 2.217

Scatter Plot of External by Institutional for Physics

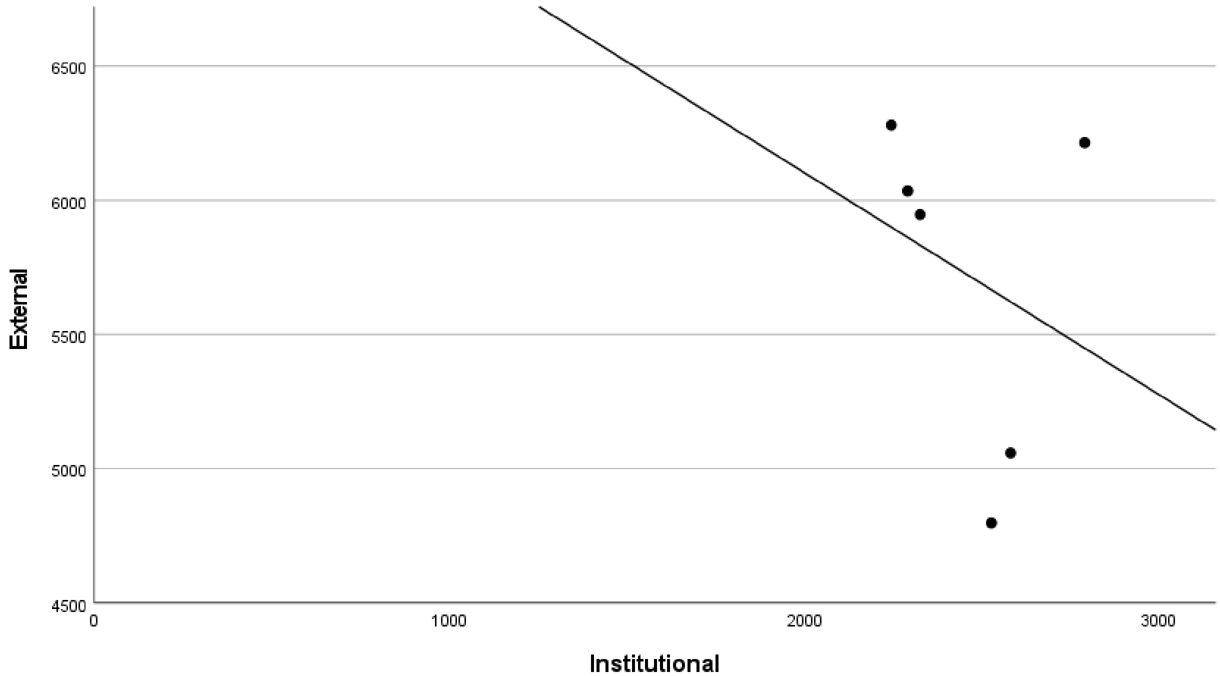


Figure 2.218

Normal Q-Q Plot of External for Physics

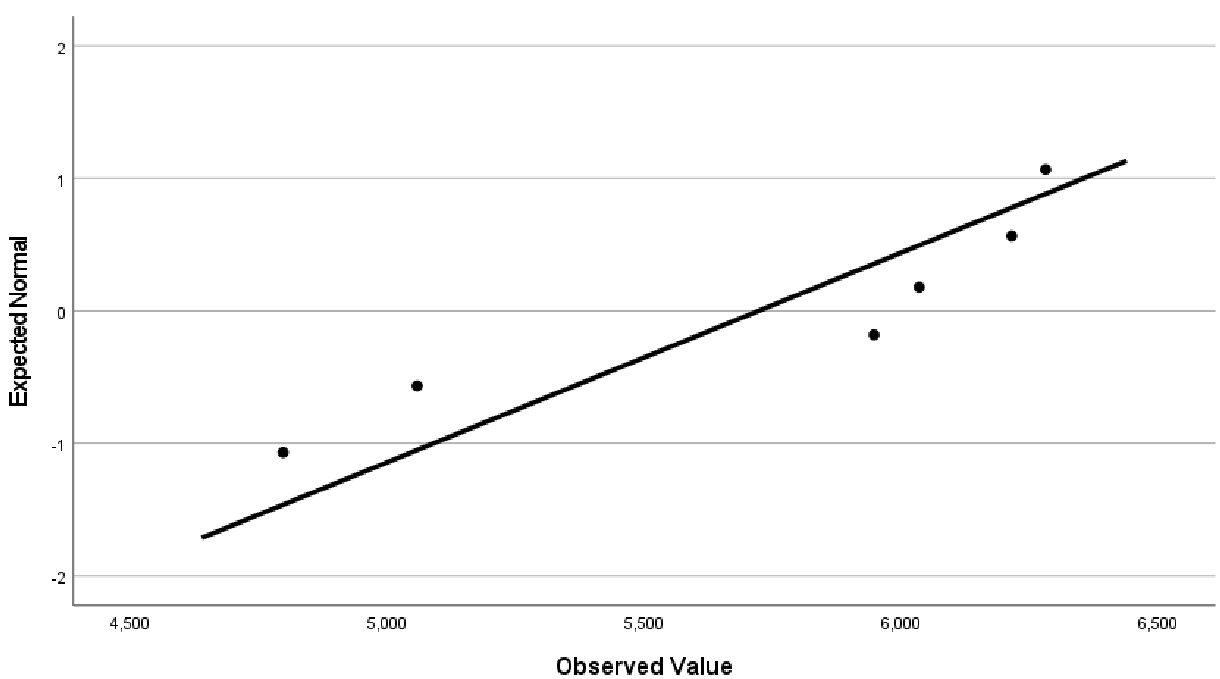


Figure 2.219

Normal P-P Plot of Regression Standardized Residual for Physics

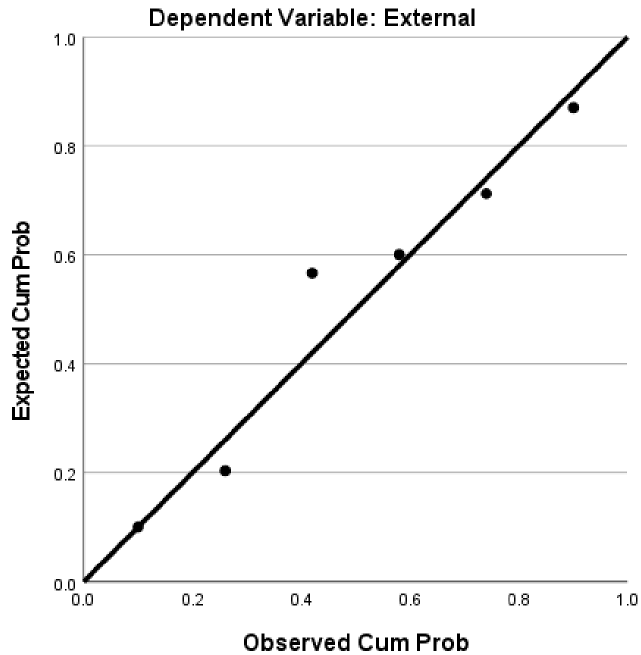
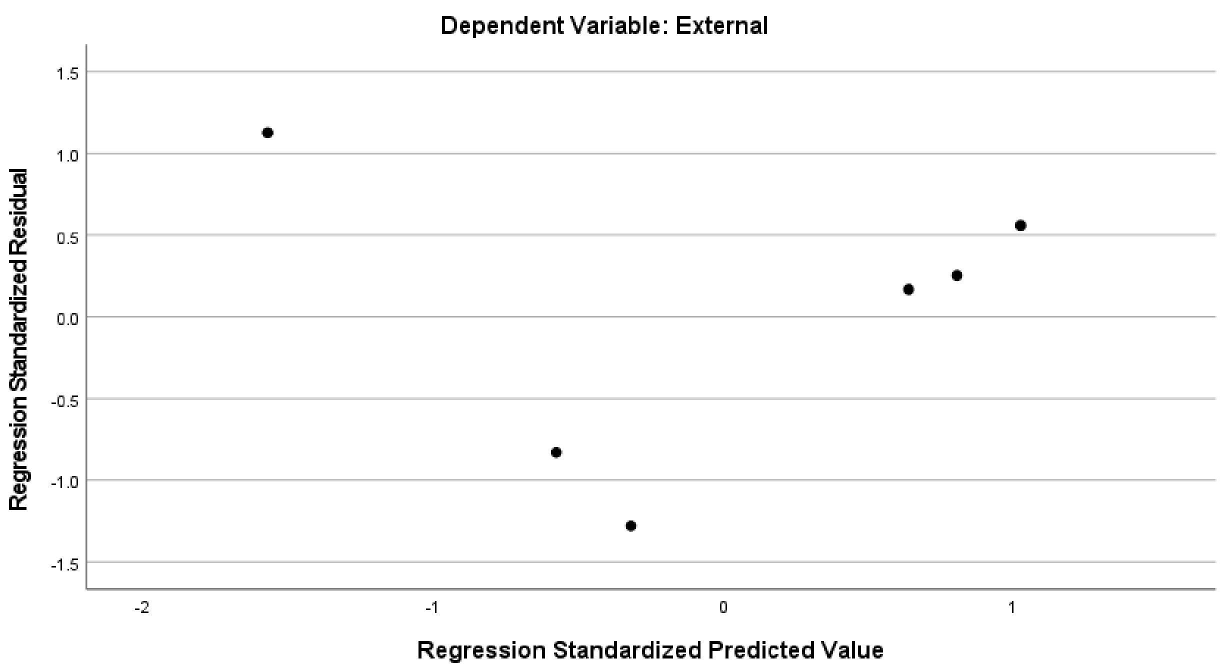


Figure 2.220

Scatterplot for Physics



Psychology

Table 2.56 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Psychology R&D expenditures. Figure 2.221 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Psychology field reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.222. Standardized residuals were somewhat normally distributed as shown in Figure 2.223 as more than half of the values fall closely on the line. Scatterplots in Figure 2.224 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Psychology field, $F(1,4) = .24$, $p = .647$. A small effect size was noted with approximately 5.8% of the variances accounted for in the model, $R^2 = .058$.

Table 2.56

Descriptive Statistics for Psychology (n = 6 and r = 0.24)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	164
2015	0	388
2016	33	993
2017	70	1142
2018	27	1265
2019	4	1136
2020	32	-
M	27.67	848.00
SD	25.161	456.89

Figure 2.221

Scatter Plot of External by Institutional for Psychology

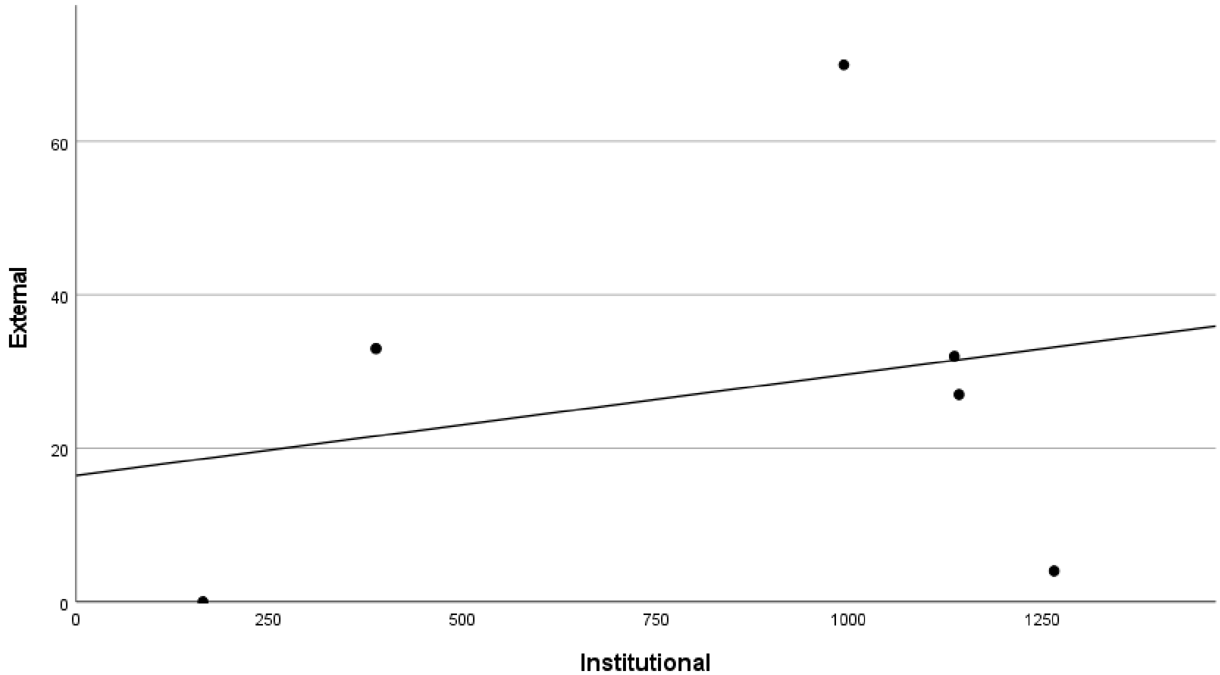


Figure 2.222

Normal Q-Q Plot of External for Psychology

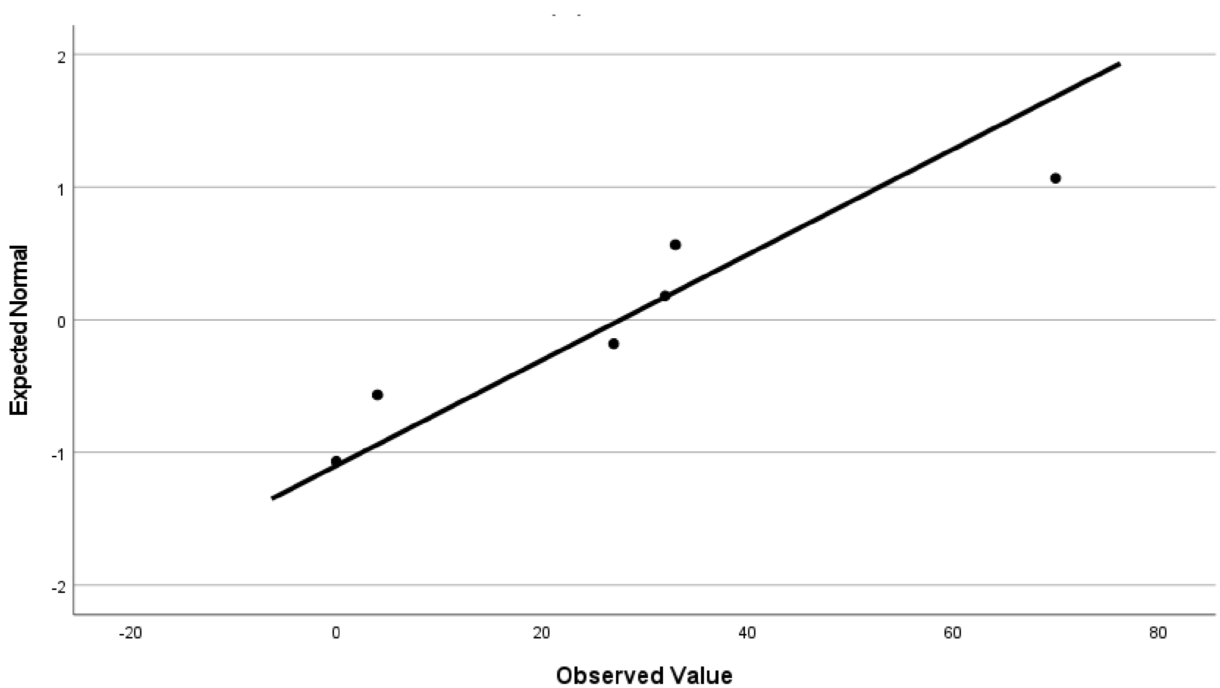


Figure 2.223

Normal P-P Plot of Regression Standardized Residual for Psychology

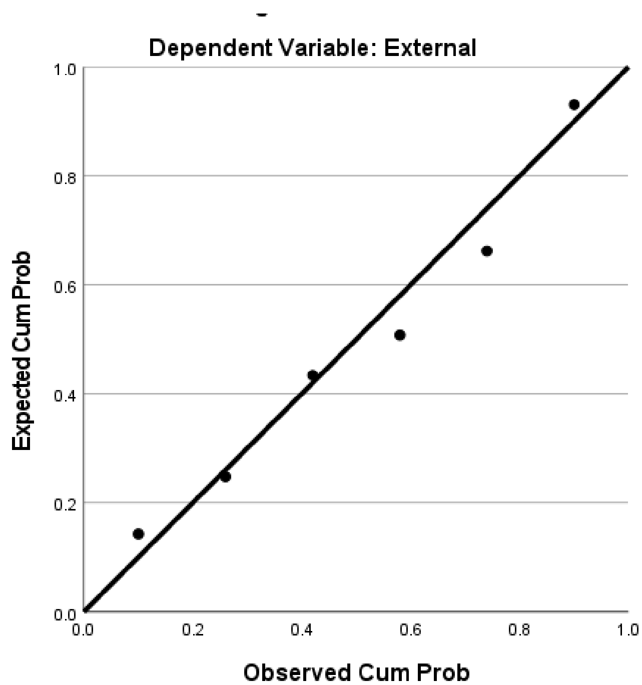
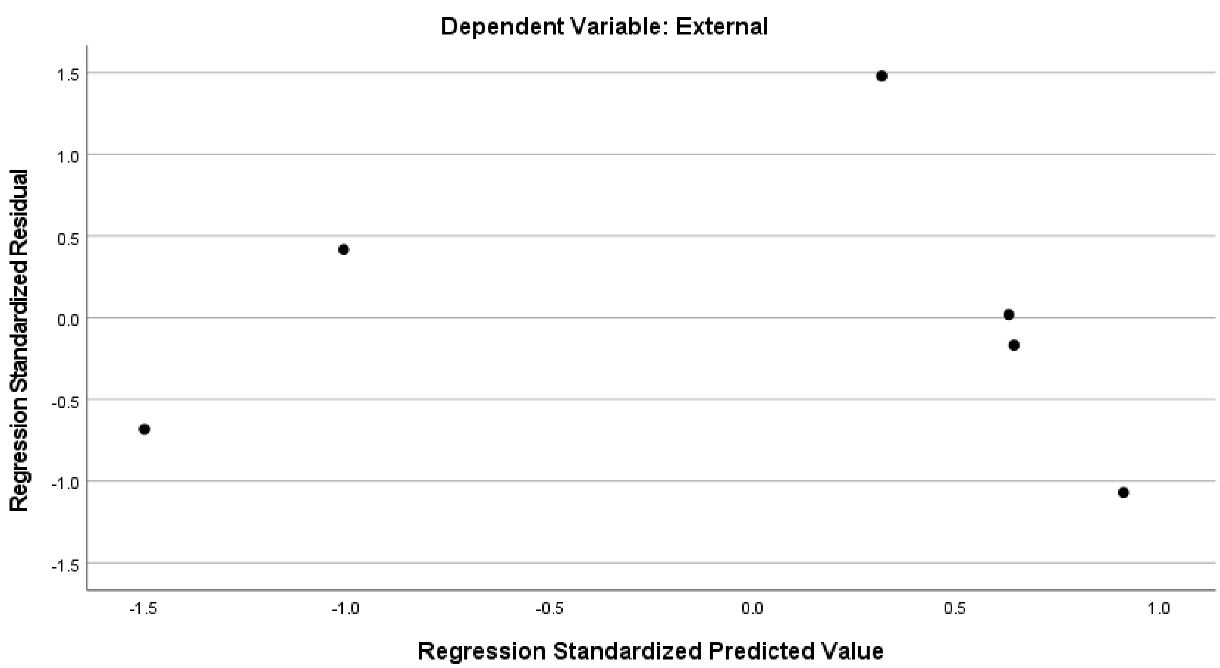


Figure 2.224

Scatterplot for Psychology



Social Sciences

Table 2.57 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Social Sciences R&D expenditures. Figure 2.225 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Social Sciences field reflecting a positive correlation. Externally funded R&D expenditures were somewhat normally distributed as shown in Figure 2.226 as half of the values fall closely on the line. Standardized residuals were not normally distributed as shown in Figure 2.227. Scatterplots in Figure 2.228 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Social Sciences field, $F(1,4) = 3.26$, $p = .145$. A large effect size was noted with approximately 44.9% of the variances accounted for in the model, $R^2 = .449$.

Table 2.57

Descriptive Statistics for Social Sciences (n = 6 and r = 0.67)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	650
2015	320	977
2016	463	4536
2017	1317	4522
2018	772	4238
2019	399	5070
2020	922	-
M	698.83	3332.17
SD	381.14	1972.12

Figure 2.225

Scatter Plot of External by Institutional for Social Sciences

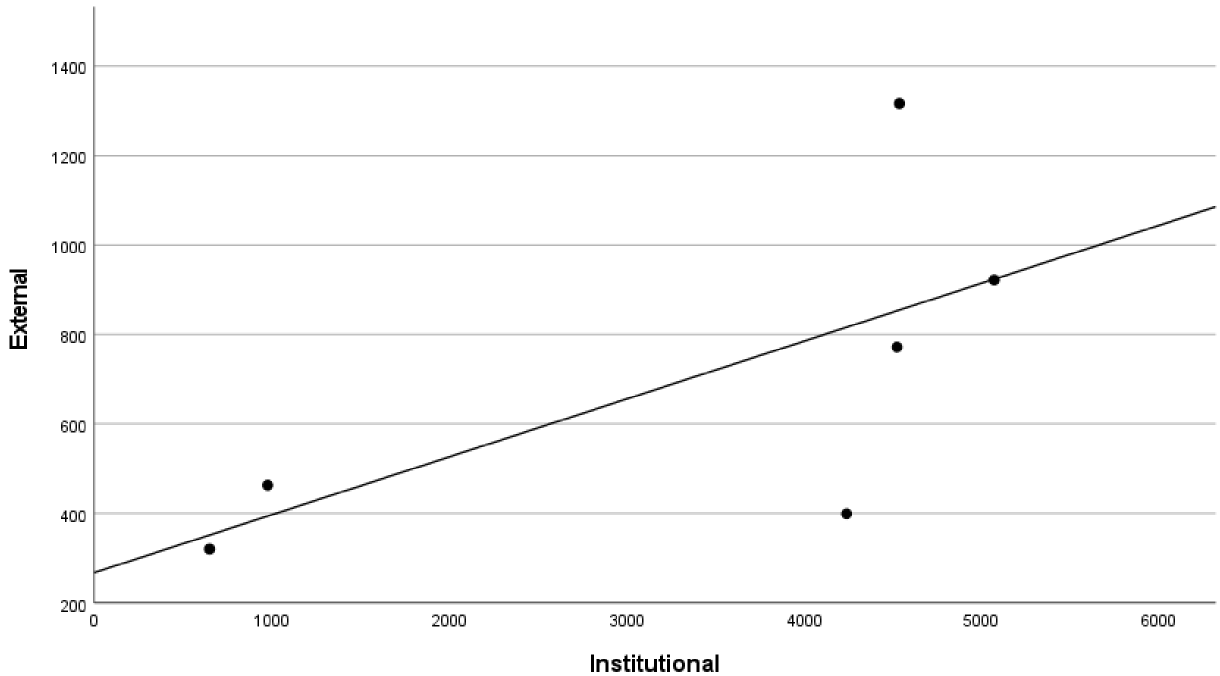


Figure 2.226

Normal Q-Q Plot of External for Social Sciences

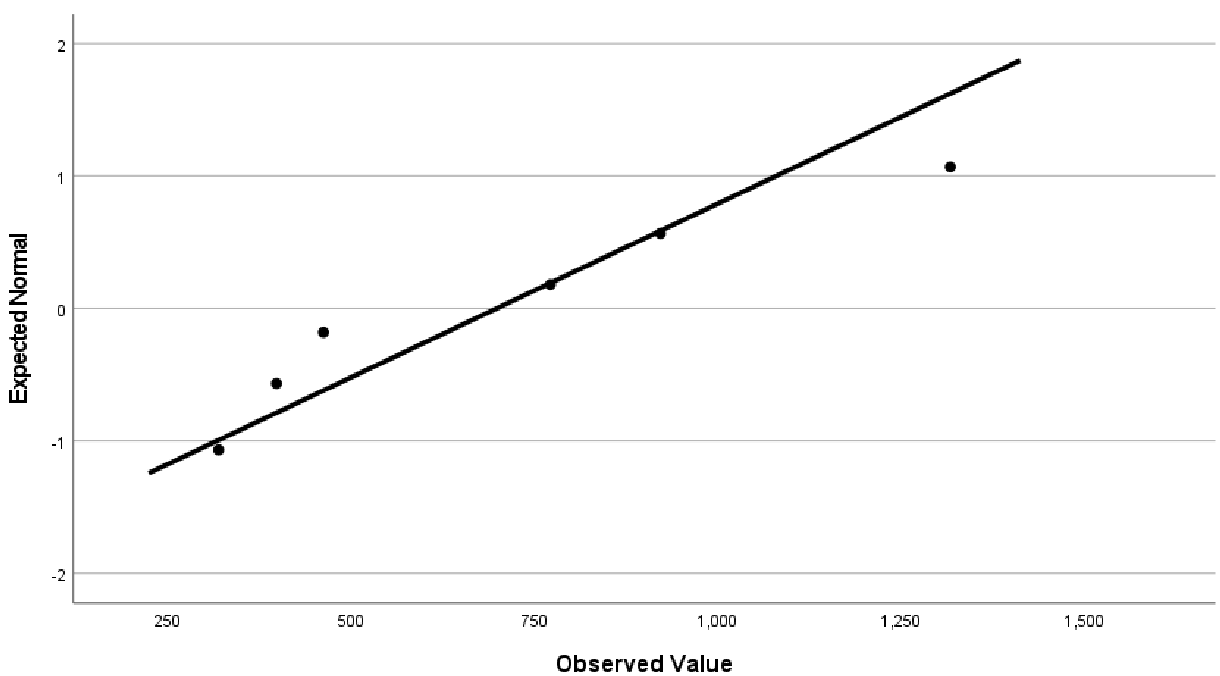


Figure 2.227

Normal P-P Plot of Regression Standardized Residual for Social Sciences

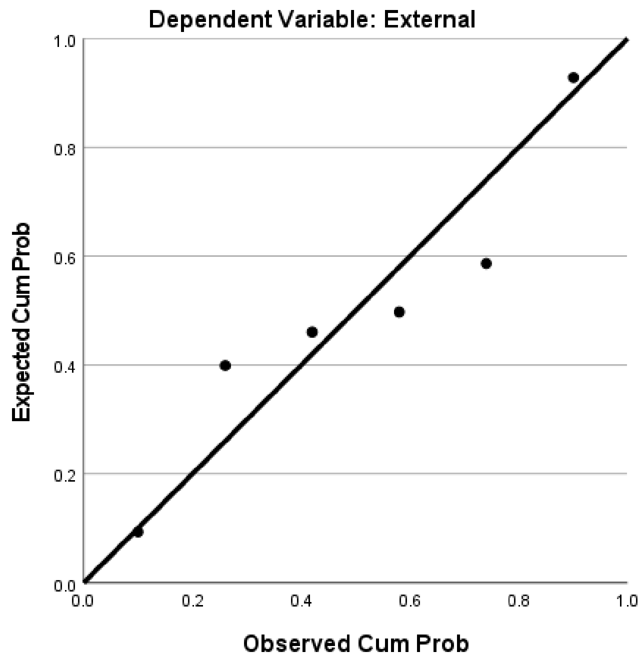
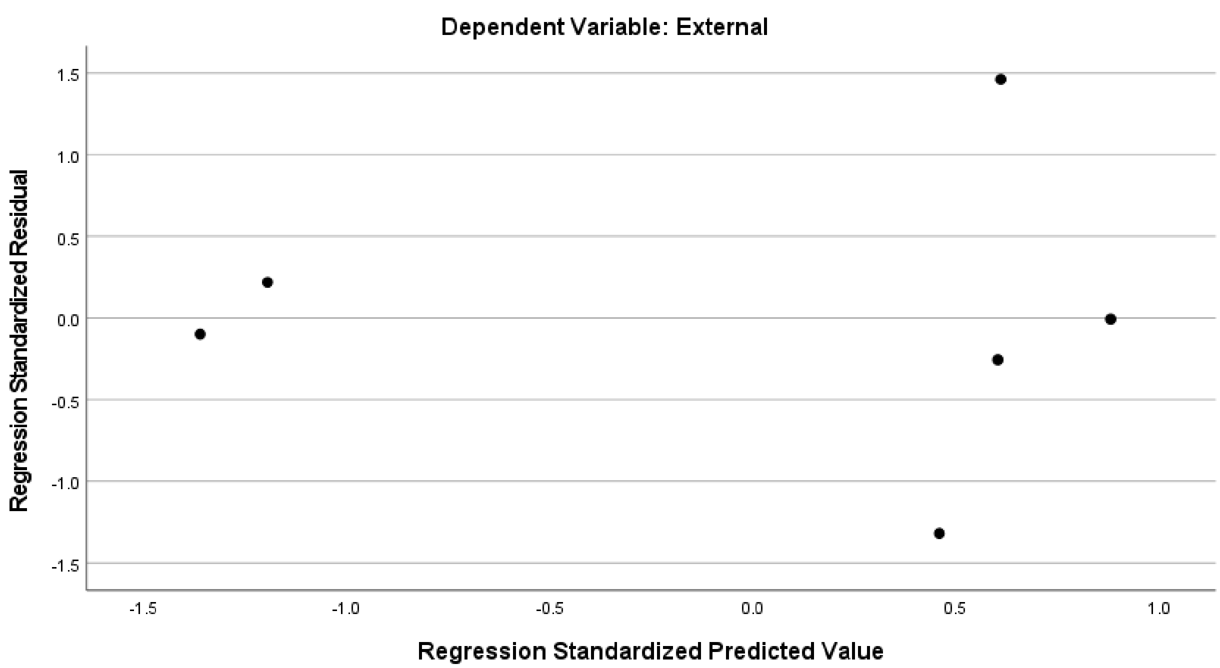


Figure 2.228

Scatterplot for Social Sciences



Political Science and Government

Table 2.58 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Political Science and Government R&D expenditures. Figure 2.229 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Political Science and Government subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.230. Standardized residuals were somewhat normally distributed as shown in Figure 2.231 as more than half of the values fall closely on the line. Scatterplots in Figure 2.232 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a statistically significant relationship between institutionally and externally funded R&D expenditures in the Political Science and Government subfield, $F(1,4) = 15.13$, $p = .018$. A large effect size was noted with approximately 79.1% of the variances accounted for in the model, $R^2 = .791$.

Table 2.58

Descriptive Statistics for Political Science and Government (n = 6 and r = 0.89)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	329
2015	4	363
2016	25	1166
2017	72	1146
2018	89	898
2019	33	1119
2020	56	-
M	46.50	836.83
SD	31.62	392.35

Figure 2.229

Scatter Plot of External by Institutional for Political Science and Government

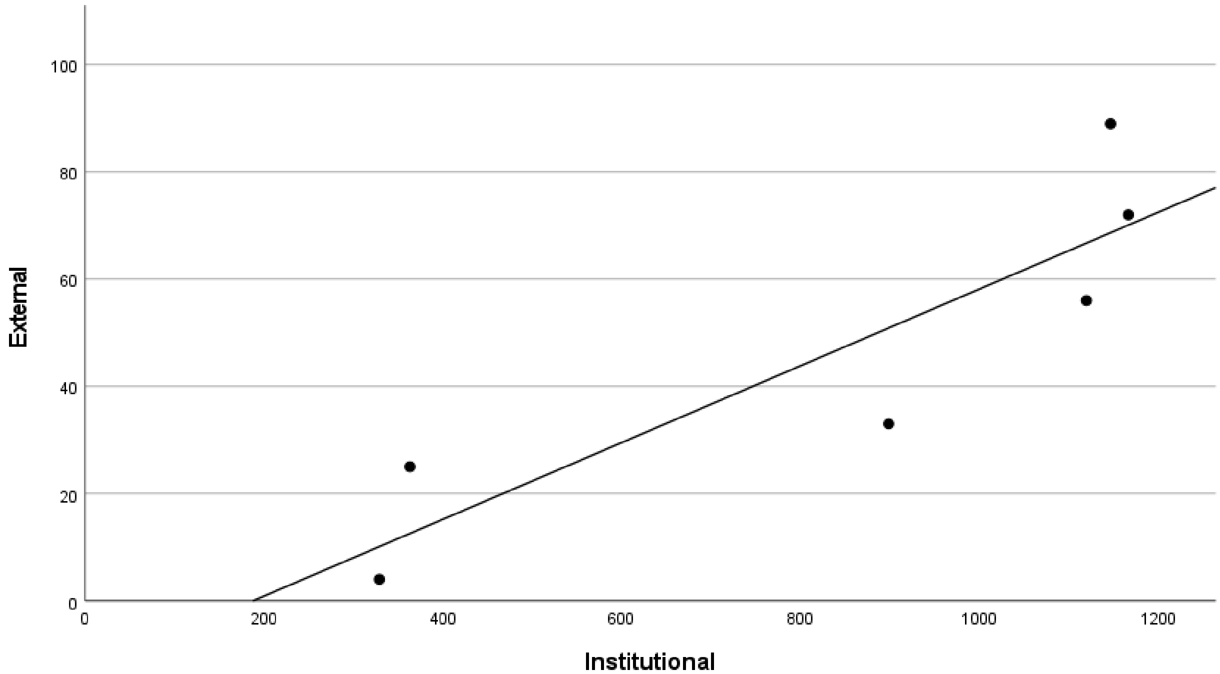


Figure 2.230

Normal Q-Q Plot of External for Political Science and Government

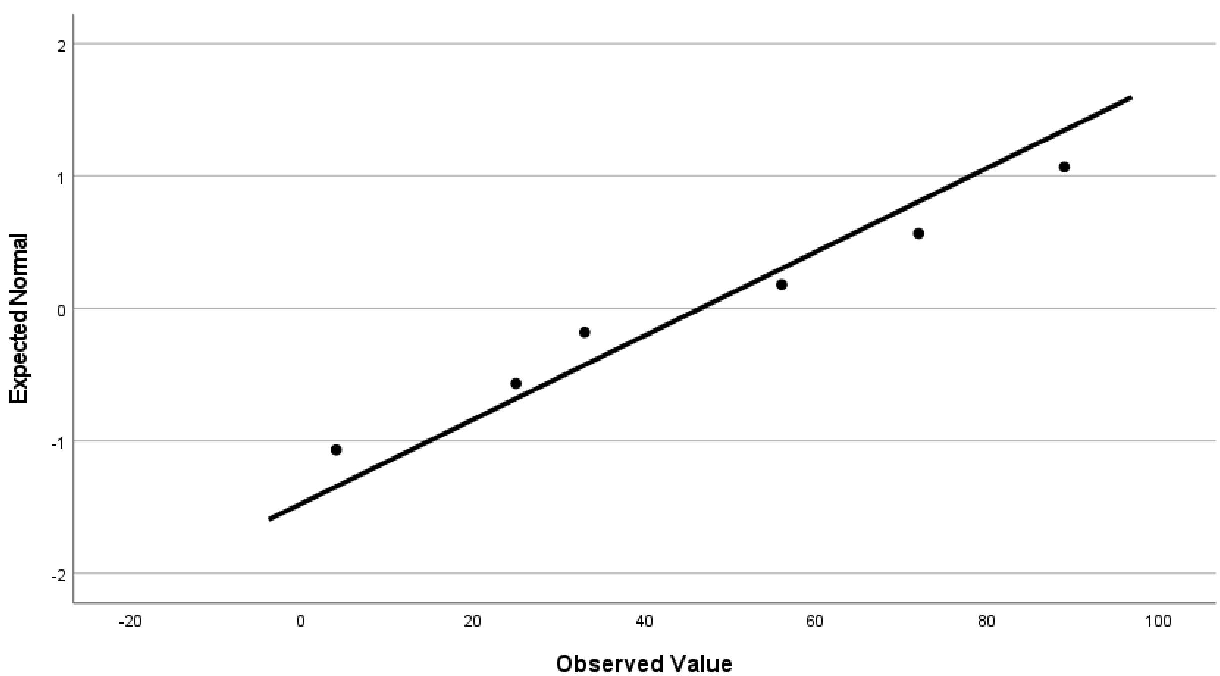


Figure 2.231

Normal P-P Plot of Regression Standardized Residual for Political Science and Government

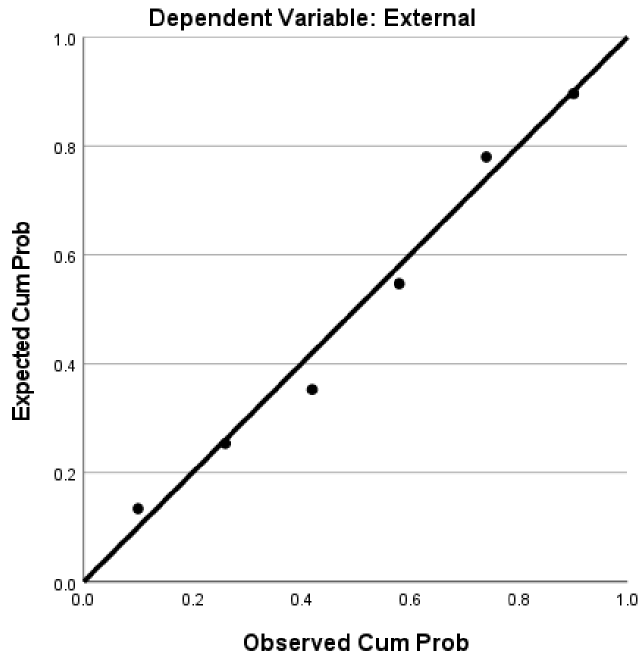
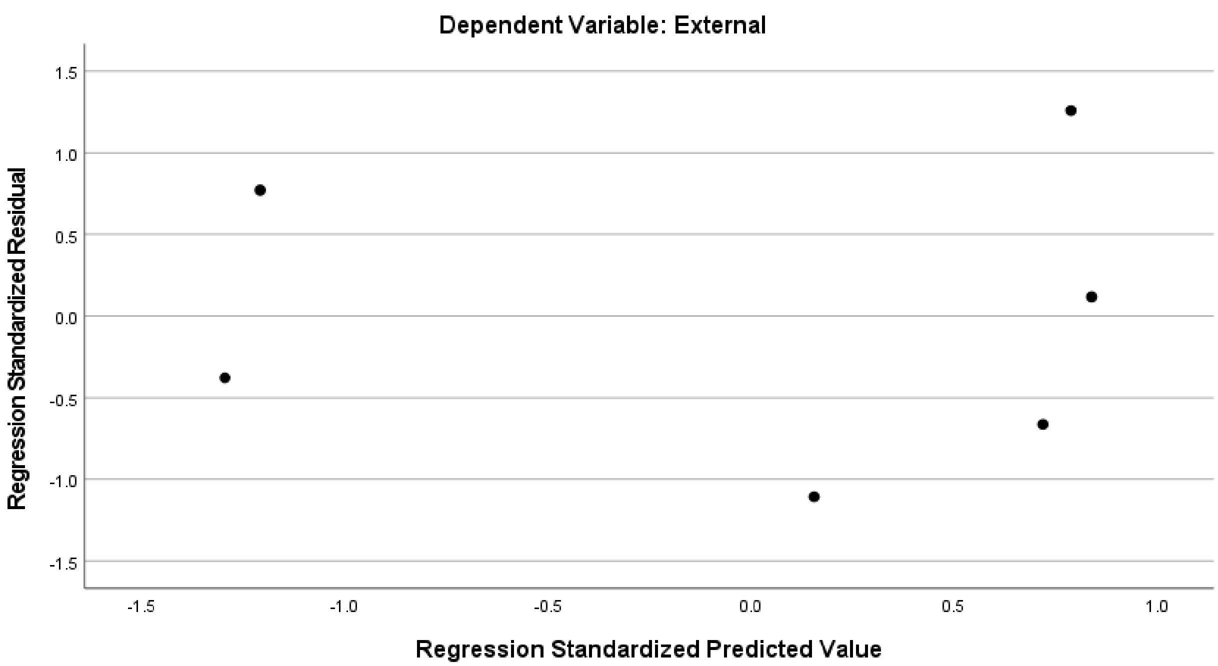


Figure 2.232

Scatterplot for Political Science and Government



Sociology, Demography, and Population Studies

Table 2.59 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Sociology, Demography, and Population (SD&P) Studies R&D expenditures. Figure 2.233 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Sociology, Demography, and Population Studies subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.234. Standardized residuals were somewhat normally distributed as shown in Figure 2.235 as more than half of the values fall closely on the line. Scatterplots in Figure 2.236 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was a not statistically significant relationship between institutionally and externally funded R&D expenditures in the Social, Demography, and Population Studies subfield, $F(1,4) = 3.68$, $p = .127$. A large effect size was noted with approximately 47.9% of the variances accounted for in the model, $R^2 = .479$.

Table 2.59

Descriptive Statistics for SD&P Studies (n = 6 and r = 0.69)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	288
2015	248	552
2016	416	1160
2017	342	1386
2018	554	1272
2019	348	1481
2020	684	-
M	432.00	1023.17
SD	159.79	486.70

Figure 2.233

Scatter Plot of External by Institutional for SD&P Studies

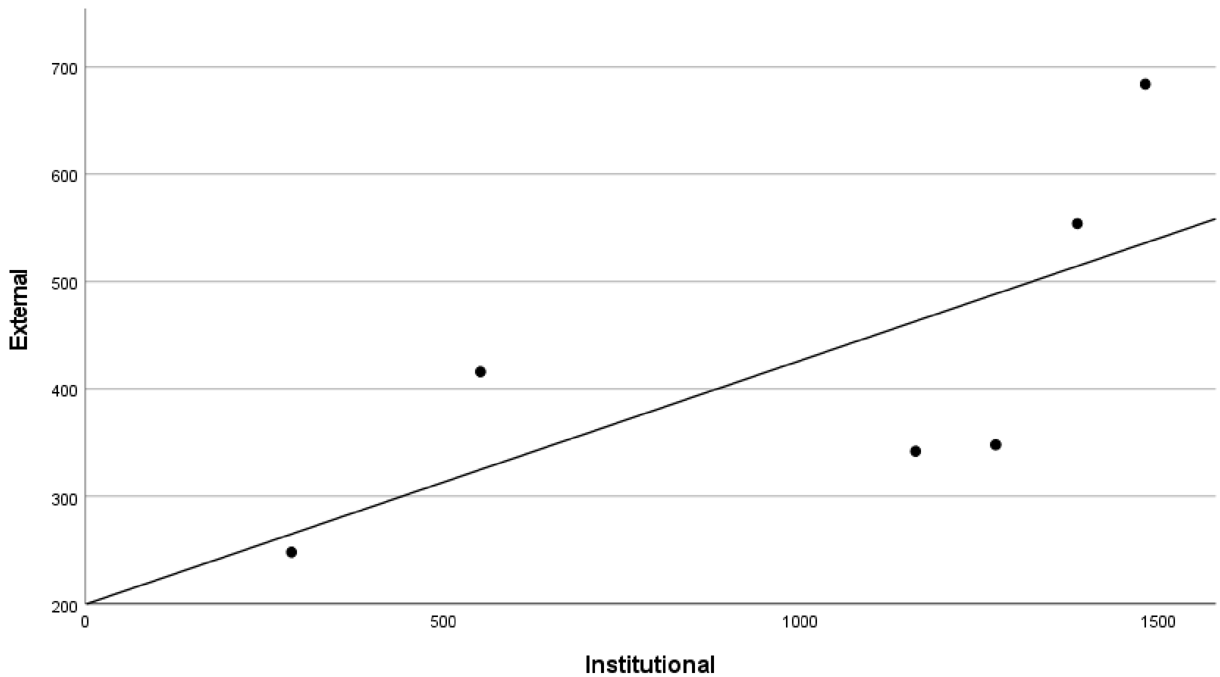


Figure 2.234

Normal Q-Q Plot of External for SD&P Studies

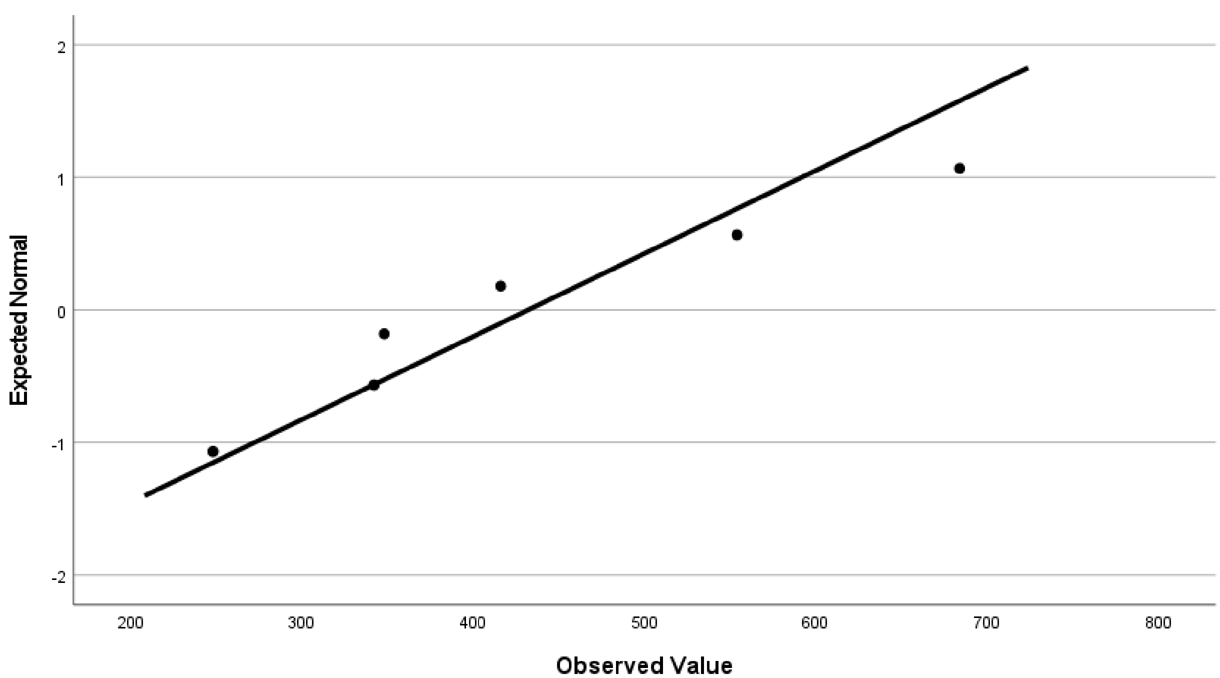


Figure 2.235

Normal P-P Plot of Regression Standardized Residual for SD&P Studies

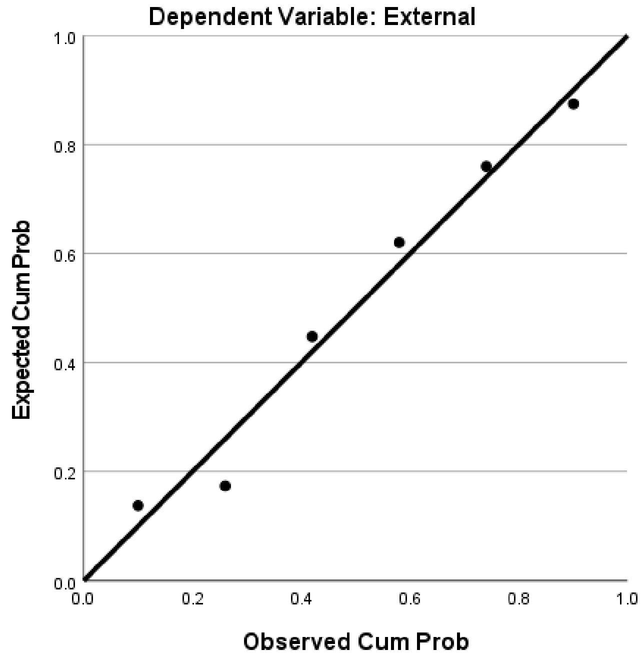
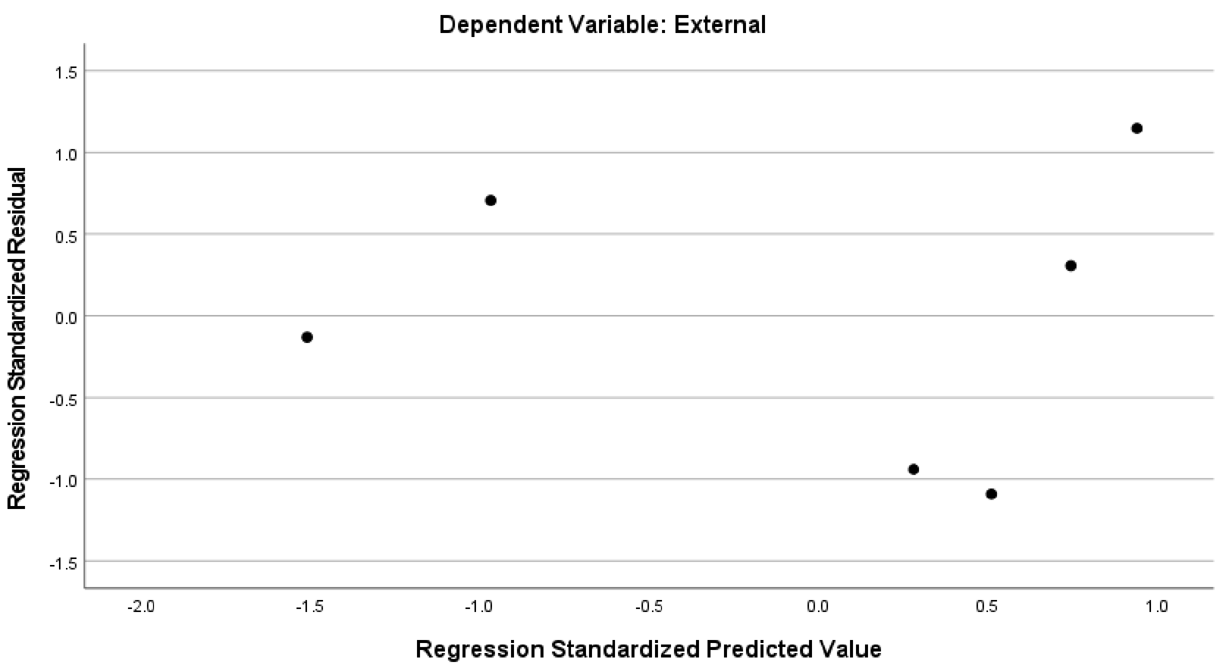


Figure 2.236

Scatterplot for SD&P Studies



Other Social Sciences

The NSF HERD Survey (n.d.) categorizes any Social Sciences fields that cannot be specifically identified within the previously listed subfields as Other Social Sciences. Table 2.60 details expenditures, mean (*M*), and standard deviation (*SD*) for externally and institutionally funded Other Social Sciences R&D expenditures. Figure 2.237 presents a simple scatterplot of the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures for the Sociology, Demography, and Population Studies subfield reflecting a positive correlation. Externally funded R&D expenditures were not normally distributed as shown in Figure 2.238. Standardized residuals were not normally distributed as shown in Figure 2.239. Scatterplots in Figure 2.240 were analyzed, and no curvilinear relationships between the criterion variable and the predictor variable or heteroscedascity were evident. There was not a statistically significant relationship between institutionally and externally funded R&D expenditures in the Other Social Sciences subfield, $F(1,4) = .33$, $p = .596$. A small effect size was noted with approximately 7.7% of the variances accounted for in the model, $R^2 = .077$.

Table 2.60

Descriptive Statistics for Other Social Sciences (n = 6 and r = 0.28)

R&D Expenditures (Dollars in thousands)		
Fiscal Year	Externally Funded	Institutionally Funded
2014	-	1
2015	68	30
2016	7	257
2017	56	16
2018	129	250
2019	18	387
2020	155	-
M	72.17	156.83
SD	59.25	162.42

Figure 2.237

Scatter Plot of External by Institutional for Other Social Sciences

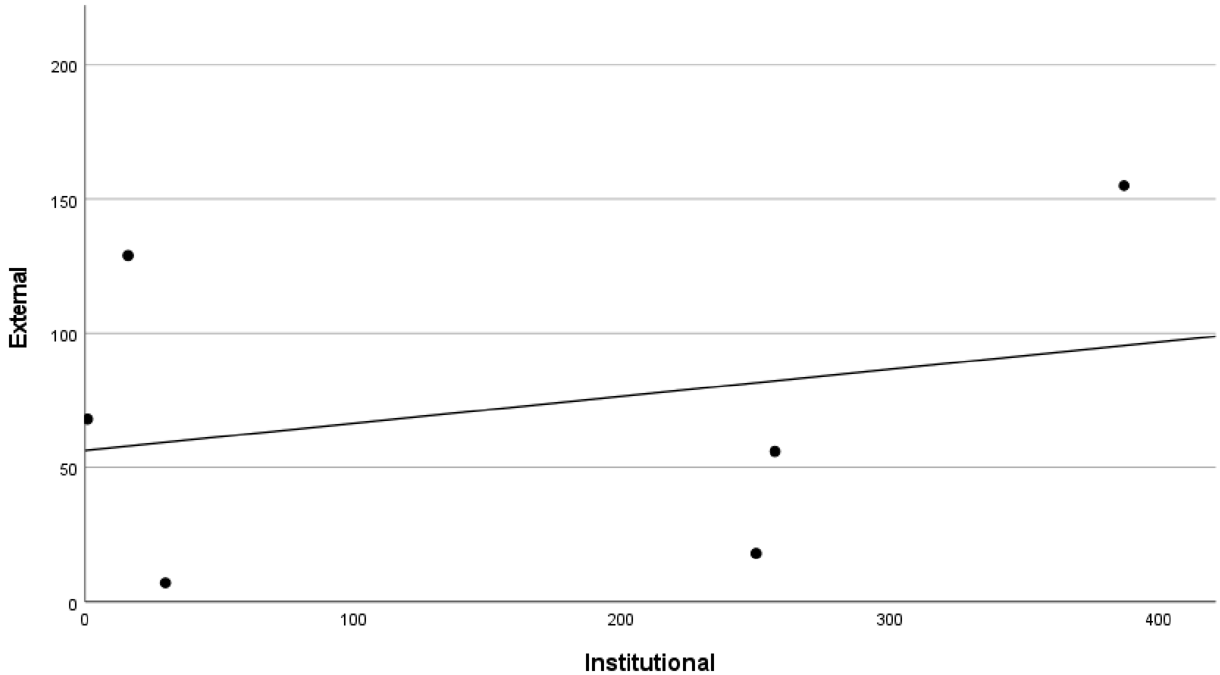


Figure 2.238

Normal Q-Q Plot of External for Other Social Sciences

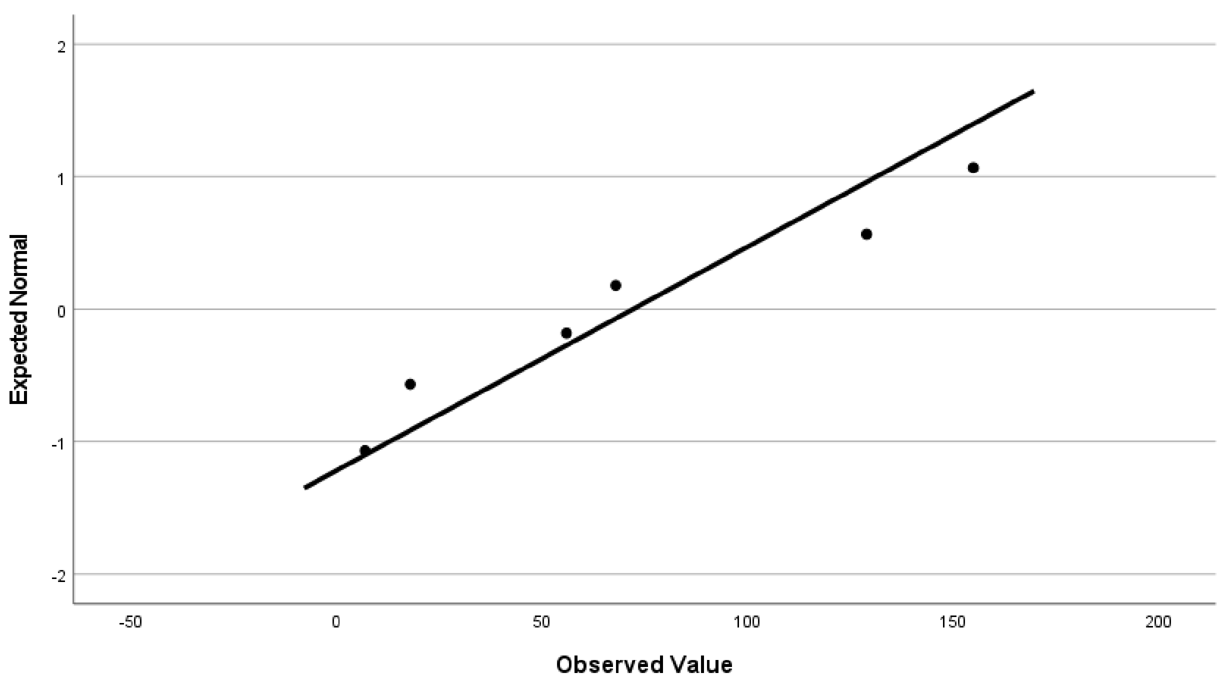


Figure 2.239

Normal P-P Plot of Regression Standardized Residual for Other Social Sciences

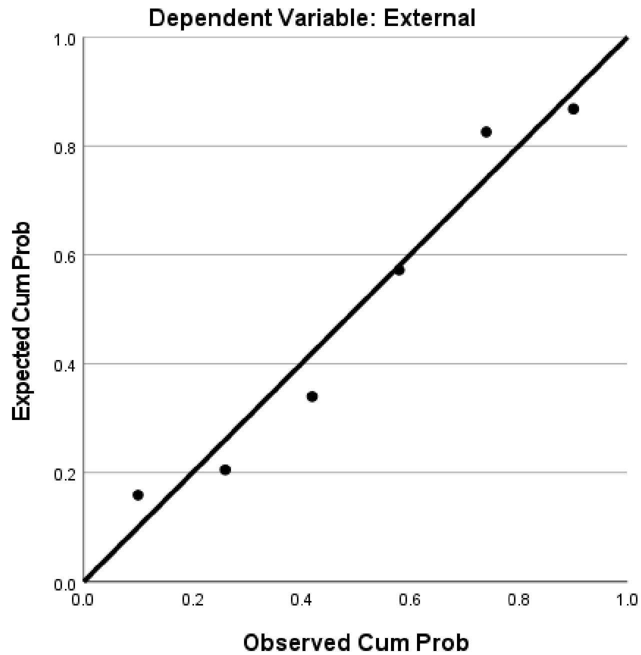
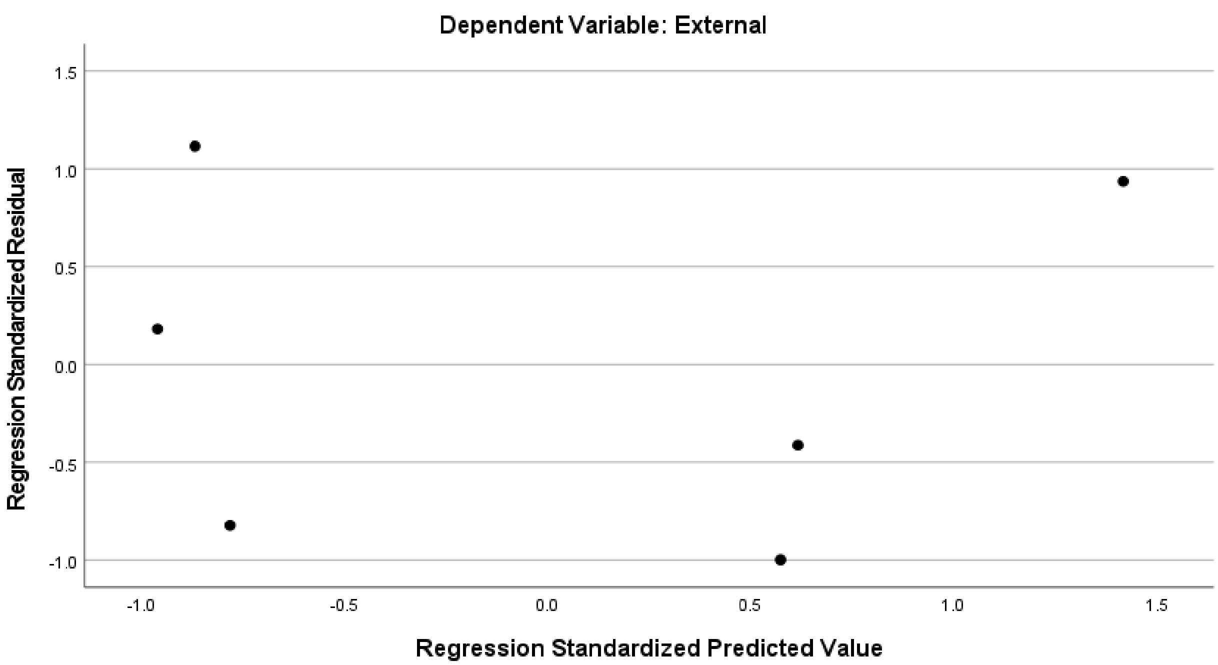


Figure 2.240

Scatterplot for Other Social Sciences



Secondary Data Analyses Trends

The simple linear regressions of institutionally funded R&D expenditures from 2014 through 2019 and externally funded R&D expenditures for the following fiscal years of 2015 through 2020 reveal differing results as summarized in Appendix B than the initial data analysis regressions performed of R&D expenditures for the same fiscal year summarized in Appendix A. A majority of the regressions (23 or 77%) are positive, with externally funded R&D expenditures increasing as institutionally funded R&D expenditures increased. Only seven fields and subfields, or 23%, are negatively correlated with externally funded R&D expenditures decreasing as institutionally funded R&D expenditures increased. The secondary analyses reveal relationships in two fields and four subfields of the NSF HERD Survey data.

Conclusion

This second manuscript of my study provided a summary of linear regression analyses of institutionally and externally funded R&D expenditures reported in the NSF HERD survey for an R1 university in the southeastern United States of America. Initial analyses were performed by field and subfield for institutionally and externally funded R&D expenditures within the same fiscal year. Secondary analyses by field and subfield were also performed for institutionally funded R&D expenditures compared to externally funded R&D expenditure for the subsequent fiscal year. The following final manuscript conveys the meaning of the data findings, identifies study limitations, and concludes with suggestions for research and practice.

List of References

National Science Foundation. (n.d.). *Higher education research and development survey (HERD)*. https://www.nsf.gov/statistics/srvyherd/#sd

List of Appendices

Appendix A – Summary Table of Initial Data Analyses

	Initial Analyses - Same Fiscal Year					
NSF HERD Survey Broad Field	Direction	*F*	*p*	*r*	*R2*	Effect Size
Computer & Information Sciences	Negative	7.34	0.054	-0.81	0.647	Large
Engineering	Negative	2.31	0.203	-0.61	0.366	Large
Geosciences, Atmospheric, & Ocean sciences (GAOS)	Negative	1.44	0.296	-0.52	0.265	Large
Life Sciences	Positive	0.33	0.598	0.28	0.075	Small
Mathematics & Statistics	Negative	0.01	0.934	-0.04	0.002	Small
Non-S&E Fields	Positive	0.03	0.871	0.09	0.007	Small
Physical Sciences	Positive	6.57	0.062	0.79	0.622	Large
Psychology	Positive	0.77	0.429	0.40	0.162	Medium
Social Sciences	Positive	0.07	0.800	0.13	0.018	Small

NSF HERD Survey Subfield	Direction	*F*	*p*	*r*	*R2*	Effect Size
Engineering - Chemical	Positive	0.19	0.683	0.22	0.046	Small
Engineering - Civil	Negative	0.09	0.783	-0.15	0.021	Small
Engineering - Electrical, Electronic, & Communications	Negative	0.77	0.431	-0.40	0.160	Medium
Engineering - Mechanical	Negative	4.12	0.112	-0.71	0.508	Large
Engineering - Other	Negative	1.43	0.297	-0.51	0.264	Large
GAOS - Geological & Earth Sciences	Positive	4.09	0.113	0.71	0.506	Large
GAOS - Ocean Sciences & Marine Sciences	Positive	3.57	0.132	0.69	0.471	Large
Life sciences - Biological & Biomedical	Positive	3.88	0.120	0.70	0.492	Large
Life Sciences - Health	Negative	0.52	0.512	-0.34	0.114	Small
Life Sciences - Other	Negative	0.25	0.644	-0.24	0.059	Small
Non-S&E Fields - Communication & Communications Tech	Positive	0.55	0.500	0.35	0.121	Small
Non-S&E Fields - Education	Negative	0.51	0.513	-0.34	0.114	Small
Non-S&E Fields - Humanities	Positive	3.46	0.136	0.68	0.464	Large
Non-S&E Fields - Law	Negative	0.05	0.842	-0.11	0.011	Small
Non-S&E Fields - Social work	Negative	0.94	0.386	-0.44	0.191	Medium
Non-S&E Fields - Other	Negative	0.60	0.480	-0.36	0.131	Medium
Physical Sciences - Chemistry	Positive	4.51	0.101	0.73	0.530	Large
Physical Sciences - Physics	Positive	0.39	0.565	0.30	0.089	Small
Social Sciences - Political Science & Government	Positive	0.24	0.652	0.24	0.056	Small
Social Sciences - Sociology, Demography, & Population Studies	Negative	0.09	0.780	-0.15	0.022	Small
Social Sciences - Other	Negative	0.81	0.418	-0.41	0.169	Medium

Appendix B – Summary Table of Secondary Data Analyses

NSF HERD Survey Broad Field	Direction	*F*	*p*		*r*	*R2*	Effect Size
Computer & Information Sciences	Negative	0.23	0.655		-0.23	0.055	Small
Engineering	Positive	0.52	0.510		0.34	0.115	Small
Geosciences, Atmospheric, & Ocean sciences (GAOS)	Negative	0.83	0.415		-0.41	0.171	Medium
Life Sciences	Positive	15.94	0.016	*	0.89	0.799	Large
Mathematics & Statistics	Positive	0.09	0.779		0.15	0.022	Small
Non-S&E Fields	Positive	37.49	0.004	*	0.95	0.904	Large
Physical Sciences	Positive	0.08	0.798		0.14	0.018	Small
Psychology	Positive	0.24	0.647		0.24	0.058	Small
Social Sciences	Positive	3.26	0.145		0.67	0.449	Large

NSF HERD Survey Subfield	Direction	*F*	*p*		*r*	*R2*	Effect Size
Engineering - Chemical	Negative	0.78	0.426		-0.41	0.164	Medium
Engineering - Civil	Positive	0.79	0.423		0.41	0.166	Medium
Engineering - Electrical, Electronic, & Communications	Positive	2.86	0.166		0.65	0.417	Large
Engineering - Mechanical	Negative	0.01	0.938		-0.04	0.002	Small
Engineering - Other	Negative	2.99	0.159		-0.65	0.427	Large
GAOS - Geological & Earth Sciences	Positive	1.92	0.238		0.57	0.324	Large
GAOS - Ocean Sciences & Marine Sciences	Positive	4.78	0.094		0.74	0.544	Large
Life sciences - Biological & Biomedical	Positive	2.32	0.202		0.61	0.367	Large
Life Sciences - Health	Positive	0.93	0.390		0.43	0.188	Medium
Life Sciences - Other	Negative	10.80	0.030	*	-0.85	0.730	Large
Non-S&E Fields - Communication & Communications Tech	Positive	14.58	0.019	*	0.89	0.785	Large
Non-S&E Fields - Education	Positive	2.29	0.205		0.60	0.364	Large
Non-S&E Fields - Humanities	Positive	2.48	0.190		0.62	0.383	Large
Non-S&E Fields - Law	Positive	86.53	<.001	*	0.98	0.956	Large
Non-S&E Fields - Social work	Positive	0.11	0.755		0.17	0.027	Small
Non-S&E Fields - Other	Positive	7.46	0.052		0.81	0.651	Large
Physical Sciences - Chemistry	Positive	0.40	0.563		0.30	0.090	Small
Physical Sciences - Physics	Negative	0.33	0.598		-0.28	0.076	Small
Social Sciences - Political Science & Government	Positive	15.13	0.018	*	0.89	0.791	Large
Social Sciences - Sociology, Demography, & Population Studies	Positive	3.68	0.127		0.69	0.479	Large
Social Sciences - Other	Positive	0.33	0.596		0.28	0.077	Small

*Value represents a statistically significant relationship between institutionally and externally funded R&D expenditures.

MANUSCRIPT III

This is the final manuscript of my dissertation in practice seeking to identify what is the relationship, if any, between institutionally and externally funded research and development (R&D) at a Carnegie R1 university located in the southeastern United States of America. The dissertation's first manuscript provides an overview of typical research costs and the return on investment (ROI) within higher education. The study's statement of the problem follows and precedes how my personal and professional backgrounds shape my understanding and views of the problem analyzed through the Carnegie Project on the Education Doctorate's (CPED) three tenets of equity, ethics, and social justice ("The Framework," n.d.). Manuscript one also includes a review of relevant literature, the study's methodology, and research questions.

Manuscript two utilizes a correlational research design methodology to test for the existence and direction of potential relationships between the predictor (independent) variable of institutionally funded R&D expenditures and the criterion (dependent) variable of externally funded R&D expenditures as reported in the National Science Foundation's (NSF) Higher Education and R&D Development (HERD) survey. This third manuscript evaluates the meanings of findings from manuscript two's linear regression analyses using a conceptual framework of the ROI of institutionally funded R&D and Connolly's (1997) relationship modeling presented in manuscript one. Manuscript three concludes with recommendations for research and practice and study limitations.

Initial Data Analyses Findings

Simple linear regressions of institutionally and externally funded R&D expenditures were performed for 30 NSF HERD Survey fields and subfields from 2015 through 2020. Descriptive statistics were presented for each field and subfield, along with scatterplots and standardized residuals.

Relationship of Institutionally and Externally Supported Research and Development

Research Question 1 (RQ1) asks how, if at all, the amount of institutional financial support of R&D relates to externally supported R&D expenditures at an R1 university. Data presented in the study's second manuscript indicate the null hypothesis is accepted, meaning institutional R&D expenditures are not a good predictor of externally funded R&D expenditures as there were no relationships identified for any field or subfield. The *p* values for each NSF field and subfield analyzed were greater than the alpha (significance) level of 0.05 as shown in Table 3.1, indicating no meaningful relationships between the independent and dependent variables of institutionally and externally supported R&D expenditures.

Table 3.1

NSF HERD Survey Field and Subfield p Values

NSF HERD Survey Field & Subfield	*p*
Computer & Information Sciences	0.054
Engineering	0.203
Engineering - Chemical	0.683
Engineering - Civil	0.783
Engineering - Electrical, Electronic, & Communications	0.431
Engineering - Mechanical	0.112
Engineering - Other	0.297
Geosciences, Atmospheric, & Ocean Sciences (GAOS)	0.296
GAOS - Geological & Earth Sciences	0.113
GAOS - Ocean Sciences & Marine Sciences	0.132
Life Sciences	0.598
Life Sciences - Biological & Biomedical	0.120
Life Sciences - Health	0.512
Life Sciences - Other	0.644
Mathematics & Statistics	0.934
Non-Science & Engineering Fields	0.871
Non-S&E Fields - Communication & Communications Tech	0.500
Non-S&E Fields - Education	0.513
Non-S&E Fields - Humanities	0.136
Non-S&E Fields - Law	0.842
Non-S&E Fields - Social work	0.386
Non-S&E Fields - Other	0.480
Physical Sciences	0.062
Physical Sciences - Chemistry	0.101
Physical Sciences - Physics	0.565
Psychology	0.429
Social Sciences	0.800
Social Sciences - Political Science & Government	0.652
Social Sciences - Sociology, Demography, & Population Studies	0.780
Social Sciences - Other	0.418

Although the regressions did not identify any statistically significant relationships, there were large effect sizes between institutionally and externally funded R&D for several fields and subfields as shown in Table 3.2. An effect size is the measurement of the relationship strength between variables (Dimitrov, 2013). The study's analyses revealed large effect sizes ($R^2 > 0.25$) for the Computer and Information Sciences field; the field of Engineering and its subfields of Mechanical Engineering and Other Engineering; the field of Geosciences, Atmospheric, and Ocean Sciences and its subfields of Geological and Earth Sciences and Ocean and Marine Sciences; and the field of Physical Sciences and its subfield of Chemistry. There were two subfields, Biological and Biomedical Sciences within the Life Sciences field and Humanities within Non-Science and Engineering fields, with large effect sizes within fields with small effect sizes ($R^2 < 0.13$). The absence of relationships found in response to RQ1 and large effect sizes noted for RQ2 indicate a Type II error attributable to the study's small population size of six years of NSF HERD Survey data. Type II errors are discussed in the study limitations section of this manuscript.

Table 3.2

NSF HERD Survey Select Field and Subfield Effect Sizes

NSF HERD Survey Field & Subfield	*R2*	Effect Size
Computer & Information Sciences	0.647	Large
Engineering	0.366	Large
Engineering - Mechanical	0.508	Large
Engineering - Other	0.264	Large
Geosciences, Atmospheric, & Ocean Sciences (GAOS)	0.265	Large
GAOS - Geological & Earth Sciences	0.506	Large
GAOS - Ocean Sciences & Marine Sciences	0.471	Large
Physical Sciences	0.622	Large
Physical Sciences - Chemistry	0.530	Large
Life Sciences	0.075	Small
Life Sciences - Biological & Biomedical	0.492	Large
Non-Science & Engineering Fields	0.007	Small
Non-S&E Fields - Humanities	0.464	Large

Variance of Relationships

Research Question 2 (RQ2) asks if any relationship is found to exist, how, if at all, does the relationship vary across R&D fields at an R1 university. RQ2 is not applicable for the initial analyses of fields and subfields with the acceptance of the null hypothesis for RQ1. Acceptance of the null hypothesis means no relationships exist between institutionally and externally funded R&D expenditures from 2015 through 2020. The nearly equal number of positive correlations (14 fields and subfields or 47%) and negative correlations (16 fields and subfields or 53%) shown in Table 3.3 between institutionally and externally funded R&D are not considered meaningful due to the absence of any identified relationships.

Table 3.3

NSF HERD Survey Field and Subfield r Values

NSF HERD Survey Field & Subfield	*r*	Direction
Computer & Information Sciences	-0.81	Negative
Engineering	-0.61	Negative
Engineering - Chemical	0.22	Positive
Engineering - Civil	-0.15	Negative
Engineering - Electrical, Electronic, & Communications	-0.40	Negative
Engineering - Mechanical	-0.71	Negative
Engineering - Other	-0.51	Negative
Geosciences, Atmospheric, & Ocean Sciences (GAOS)	-0.52	Negative
GAOS - Geological & Earth Sciences	0.71	Positive
GAOS - Ocean Sciences & Marine Sciences	0.69	Positive
Life Sciences	0.28	Positive
Life Sciences - Biological & Biomedical	0.70	Positive
Life Sciences - Health	-0.34	Negative
Life Sciences - Other	-0.24	Negative
Mathematics & Statistics	-0.04	Negative
Non-Science & Engineering Fields	0.09	Positive
Non-S&E Fields - Communication & Communications Tech	0.35	Positive
Non-S&E Fields - Education	-0.34	Negative
Non-S&E Fields - Humanities	0.68	Positive
Non-S&E Fields - Law	-0.11	Negative
Non-S&E Fields - Social work	-0.44	Negative
Non-S&E Fields - Other	-0.36	Negative
Physical Sciences	0.79	Positive
Physical Sciences - Chemistry	0.73	Positive
Physical Sciences - Physics	0.30	Positive
Psychology	0.40	Positive
Social Sciences	0.13	Positive
Social Sciences - Political Science & Government	0.24	Positive
Social Sciences - Sociology, Demography, & Population Studies	-0.15	Negative
Social Sciences - Other	-0.41	Negative

Secondary Data Analyses Findings

Manuscript two includes additional analyses exploring the potential existence of relationships between institutionally and externally funded R&D expenditures utilizing a delay of one fiscal year. Simple linear regressions were performed for the same 30 NSF HERD Survey fields and subfields with the predictor (independent) variable of institutionally funded R&D expenditures from 2014 through 2019 compared to the criterion (dependent) variable of externally funded R&D expenditures for the following fiscal years of 2015 through 2020. Descriptive statistics were presented for each field and subfield, along with scatterplots and standardized residuals.

Relationship of Institutionally and Externally Supported Research and Development

The secondary data analyses result in the rejection of the null hypothesis for RQ1, meaning institutional R&D expenditures are a good predictor of externally supported R&D for two fields and four subfields shown in bold in Table 3.4. Linear regressions performed utilizing a one fiscal year delay identified linear relationships between institutional and external financial support of R&D expenditures with p values less than the alpha (significance) level of 0.05 for the fields of Life Sciences and Non-Science and Engineering and the subfields of Other Life Sciences, Communication and Communications Technologies, Law, and Political Science and Government.

Table 3.4

NSF HERD Survey Field and Subfield p Values Utilizing One Fiscal Year Delay

NSF HERD Survey Field & Subfield	*p*
Computer & Information Sciences	0.655
Engineering	0.510
Engineering - Chemical	0.426
Engineering - Civil	0.423
Engineering - Electrical, Electronic, & Communications	0.166
Engineering - Mechanical	0.938
Engineering - Other	0.159
Geosciences, Atmospheric, & Ocean Sciences (GAOS)	0.415
GAOS - Geological & Earth Sciences	0.238
GAOS - Ocean Sciences & Marine Sciences	0.094
Life Sciences	**0.016**
Life Sciences - Biological & Biomedical	0.202
Life Sciences - Health	0.390
Life Sciences - Other	**0.030**
Mathematics & Statistics	0.779
Non-Science & Engineering Fields	**0.004**
Non-S&E Fields - Communication & Communications Tech	**0.019**
Non-S&E Fields - Education	0.205
Non-S&E Fields - Humanities	0.190
Non-S&E Fields - Law	**<.001**
Non-S&E Fields - Social work	0.755
Non-S&E Fields - Other	0.052
Physical Sciences	0.798
Physical Sciences - Chemistry	0.563
Physical Sciences - Physics	0.598
Psychology	0.647
Social Sciences	0.145
Social Sciences - Political Science & Government	**0.018**
Social Sciences - Sociology, Demography, & Population Studies	0.127
Social Sciences - Other	0.596

All six relationships noted between institutionally and externally funded R&D expenditures had large effect sizes (R^2) ranging from 0.730 to 0.956 shown in bold in Table 3.5. Even with the rejection of the null hypothesis for RQ1 and large effect sizes noted for the six relationships, there is still the potential for the existence of Type II errors due to the small population sample size discussed further in the study limitations section of this manuscript.

Table 3.5

NSF HERD Survey Select Field and Subfield Effect Sizes Utilizing One Fiscal Year Delay

NSF HERD Survey Field & Subfield	*R2*	Effect Size
Life Sciences	**0.799**	Large
Life Sciences - Other	**0.730**	Large
Non-Science & Engineering Fields	**0.904**	Large
Non-S&E Fields - Communication & Communications Tech	**0.785**	Large
Non-S&E Fields - Law	**0.956**	Large
Social Sciences	0.449	Large
Social Sciences - Political Science & Government	**0.791**	Large

Variance of Relationships

Research Question 2 (RQ2) asks if any relationship is found to exist, how, if at all, does the relationship vary across R&D fields at an R1 university. The secondary analyses with the delay of one fiscal year between the independent and dependent variables reveal predominantly positive correlational relationships between institutionally and externally funded R&D expenditures as shown in Table 3.6. Five of the six statistically significant relationships identified were positive. The positive correlations indicate that as institutionally funded R&D expenditures increase, so do the following year's externally funded R&D expenditures for the fields of Life Sciences and Non-Science and Engineering, as well as the Communications and Communications Technologies, Law and Political Science and Government subfields. A negative correlation was noted for the Other Life Sciences subfield reflecting decreases in the subsequent year of externally funded R&D expenditures compared to prior year increases of institutionally funded R&D expenditures. The 24 NSF HERD Survey fields and subfields not found to have relationships ($p > 0.05$) were more positively skewed using the one fiscal year lag compared to the year over year analysis. The one fiscal year lag resulted in 23 or 77% of positive correlations indicative of increases in externally funded R&D expenditures compared to the prior year's institutionally funded R&D expenditures.

Table 3.6

NSF HERD Survey Field and Subfield r Values Utilizing One Fiscal Year Delay

NSF HERD Survey Field & Subfield	*r*	Direction
Computer & Information Sciences	-0.23	Negative
Engineering	0.34	Positive
Engineering - Chemical	-0.41	Negative
Engineering - Civil	0.41	Positive
Engineering - Electrical, Electronic, & Communications	0.65	Positive
Engineering - Mechanical	-0.04	Negative
Engineering - Other	-0.65	Negative
Geosciences, Atmospheric, & Ocean Sciences (GAOS)	-0.41	Negative
GAOS - Geological & Earth Sciences	0.57	Positive
GAOS - Ocean Sciences & Marine Sciences	0.74	Positive
Life Sciences	**0.89**	**Positive**
Life Sciences - Biological & Biomedical	0.61	Positive
Life Sciences - Health	0.43	Positive
Life Sciences - Other	**-0.85**	**Negative**
Mathematics & Statistics	0.15	Positive
Non-Science & Engineering Fields	**0.95**	**Positive**
Non-S&E Fields - Communication & Communications Tech	**0.89**	**Positive**
Non-S&E Fields - Education	0.60	Positive
Non-S&E Fields - Humanities	0.62	Positive
Non-S&E Fields - Law	**0.98**	**Positive**
Non-S&E Fields - Social work	0.17	Positive
Non-S&E Fields - Other	0.81	Positive
Physical Sciences	0.14	Positive
Physical Sciences - Chemistry	0.30	Positive
Physical Sciences - Physics	-0.28	Negative
Psychology	0.24	Positive
Social Sciences	0.67	Positive
Social Sciences - Political Science & Government	**0.89**	**Positive**
Social Sciences - Sociology, Demography, & Population Studies	0.69	Positive
Social Sciences - Other	0.28	Positive

Recommendations for Research and Practice Suggestions

The preceding summaries of initial and secondary data analyses in response to the study's research questions serve as a foundation for making recommendations for research and practice. The relationships identified and the existence of more positive correlations within the secondary data analyses of manuscript two are consistent with Connolly's (1997) relationship modeling findings and are the basis from which I posit suggestions for research and practice.

Research Recommendations

The findings from this study's secondary data analyses serve as a starting point to obtain additional insight through further research. To decrease the potential for Type II errors, I suggest increasing the population sample size in two ways. First, I recommend **repeating the linear regression analyses of institutionally funded R&D expenditures and externally funded R&D expenditures for the subsequent fiscal year for the same university in future years.** Additional regression analyses over a more extended period would result in a larger population sample size, thereby decreasing the potential for Type II errors discussed in the study limitation section of this manuscript. Second, **the population sample size could be increased by including other Carnegie R1 universities located in the southeastern United States of America to reduce the risk of Type II errors**. The inclusion of other universities would support the validity of the current study's findings if relationships were identified in the same NSF HERD Survey fields and subfields.

Another research recommendation is to **analyze relationships identified across Carnegie R1 universities based on non-financial variables**. The NSF HERD Survey captures demographic information of R&D personnel including sex, citizenship, and level of education. Full-time equivalents (FTEs) by function of researchers, R&D technicians, and R&D support staff are also reported in the survey. Analysis of these NSF HERD Survey qualitative factors might identify similarities or relationships among institutions providing institutional leaders with additional information when considering support of R&D. Another non-financial evaluation opportunity would be to compare and contrast institutional relationships identified based upon square footage reported in NSF's biannual Survey of Science and Engineering Research Facilities (Survey of Science and Engineering Research Facilities, n.d.). Consideration of both financial and non-financial variables would provide increased insight when evaluating support of R&D.

Practice Suggestions

This section provides three suggestions for practice based on study findings. These suggestions can assist universities in maximizing the ROI from institutionally supported R&D expenditures.

Frequency of Analyses

The first suggestion for practice is that correlational analyses should be performed annually to identify the existence and direction of relationships between institutionally and externally supported R&D expenditures. Routine linear regression analyses such as the ones performed in this study would identify changes in R&D fields and subfields areas where significance levels are increasing or decreasing. Additionally, annual results could be compared to peer institutions for benchmarking.

Positive Correlational Relationships

Positive correlational relationships mean that externally supported R&D expenditures increase as institutionally funded R&D expenditures increase. Higher education leaders charged with the management of financial resources could direct institutional financial resources within

R&D fields or subfields found to have positive correlational relationships. This alignment of financial resources in areas with the greatest ROI of institutional financial support of R&D could maximize the receipt of externally supported R&D at the institution.

Negative Correlational Relationships

A negative correlational relationship indicates externally supported R&D expenditures decrease as institutionally funded R&D expenditures increase. Negative correlational relationships ($r < 0$) should be reviewed by institutional leadership to identify contributing factors and determine what course of action, if any, is appropriate as the negative relationship would not necessarily require corrective action.

A negative correlational relationship does not always indicate supplanting or redirection of institutional funds to non-R&D operational needs. Institutional support of R&D decreases in a given field or subfield once R&D becomes primarily supported through external sources such as federal agencies, state and local governments, and other for-profit or non-profit entities. Institutions track these sources of external support separate from internal support in underlying accounting records. If institutional personnel's work is supported by external entities, an appropriate percentage of their payroll cost distribution is charged to externally restricted accounts. An individual's effort cannot exceed 100%. Accordingly, as the percentage of effort devoted to R&D externally funded through grants and contracts increases, the institutional effort percentage must decrease requiring less institutional financial support for the researcher' salary. The released salary amounts may then be expended for other research endeavors.

Qualitatively analyzing negative correlations could reveal strategic or other circumstances that would validate or further support institutional investment of financial resources within the area. Competing priorities should be considered in financial decisions to align resources with strategic goals for an institution.

Study Limitations

Dimitrov (2013) describes two types of errors that can occur during hypothesis testing utilizing statistical analyses. A Type I error results when the null hypothesis or non-existence of a relationship is rejected in error, meaning a researcher concludes there is a relationship among variables when there is none based upon an acceptable level of significance or alpha level (Dimitrov, 2013). Researchers control the acceptable probability of making a Type I error when establishing the alpha level for a study (Dimitrov, 2013).

Cresswell and Guetterman (2019) describe a type II error as failing to reject the null hypothesis when an actual effect occurs within a population. Dimitrov (2013) states that with all other conditions being equal, there is an inverse relationship between the probability of making a Type II error and the alpha or selected level of significance. An alpha of 0.01 is more likely to result in failing to reject a null hypothesis than an alpha of 0.05 (Dimitrov, 2013). This study utilizes an alpha level of 0.05, meaning accepting up to a 5% chance of making a Type I error or concluding there is a relationship between institutionally and externally funded R&D when there is none.

The research design described in manuscript one included statistical data analysis over ten years from July 1, 2009, through June 30, 2019. While compiling data, I realized the university selected for testing did not attain R1 status as classified by the Carnegie Classification of Institutions of Higher Education until the fiscal year ended June 30, 2016. I limited the period for analysis to the six years in which the institution was classified as an R1 from July 1, 2014, through June 30, 2020. Future studies of institutionally and externally funded R&D expenditures of an R1 institution over a more extended period would decrease the potential for Type II errors or false negatives where the statistical results do not reflect the existence of relationships between institutional and external R&D expenditures when relationships exist. Assuming the institution analyzed in this study retains its R1 status, performing the simple linear regression analysis in another ten years might identify more relationships in fields or subfields between institutional and external funded R&D. One could also include additional R1 institutions to expand the population size when testing for the existence of relationships.

Conclusion

This third and final manuscript presents interpretations of analyses performed as part of my study of the existence and direction of relationships between institutionally and externally supported R&D expenditures at a Carnegie R1 university located in the southeastern United States of America. The study of relationships between institutional and external support of R&D was undertaken in response to a marked decline in federal support of R&D within higher education as well as limited funding of less than 10% each provided by state and local governments, businesses, and non-profit entities (National Science Foundation, 2018). Leaders of institutions of higher learning must carefully navigate decisions to allocate appropriate financial resources in support of R&D. The suggestions for research and practice are based on the results of the study's correlational research design and are influenced by my professional and personal positionality. Return on investment is not the only consideration for funding decisions by higher education finance professionals. However, appropriate consideration of the ROI can allow colleges and universities to maximize institutional financial resources when other factors are considered equal.

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