DEGREE PRODUCTION IN PUBLIC RESEARCH UNIVERSITIES IN THE UNITED STATES: AN ECONOMETRIC ANALYSIS OF ACADEMIC DEPARTMENTS

by

FRANKLIN MAURICIO SAAVEDRA CAPELO

(Under the Direction of James C. Hearn)

ABSTRACT

Given the importance of degree production due to the impending demand for highly skilled graduates in the current knowledge-intensive economy, this study focused on examining the association between departmental factors in academic units in public research universities in the United States and the number of bachelor's degrees, master's degrees, and doctoral degrees conferred by each of these units taking into account quality and field of study. As such, three research questions considering the departments' instructional type (i.e. mix of tenured/tenure track faculty, adjunct faculty, and graduate assistants); size (i.e. total instructional FTE); and financial resources (i.e. instructional expenditures and research expenditures) were proposed. To examine the research questions, this study applied the concept of production function together with utility maximization theory and academic capitalism theory as its conceptual framework. Based on this conceptual framework, six hypotheses were elaborated. The research questions and hypotheses were examined by analyzing data on academic units representing different fields of study in AAU public research universities. Multivariate seemingly unrelated regression (SUR) was employed to estimate the various equations simultaneously using Feasible Generalized Least Squares (FGLS) estimation and a double-log model. Overall, this study found that size had the greatest effect on degree production across all three degree types (bachelor's degrees, master's degrees, and doctoral degrees) while the effect of instructional type and financial resources varied by type of degree. When considering production by field of study, business management produced the greatest amount of master's degrees. Partial evidence was found for business management producing the greatest amount of bachelor's degrees and STEM producing the greatest amount of doctoral degrees. Based on the findings, this study observed a tradeoff between baccalaureate degree production and the production of doctoral degrees, as well as, a potential tradeoff between baccalaureate degree production and the production of research. Such tradeoff respectively poses concern given the mission of public research universities, President Barack Obama's 2020 goal, and the need to meet the impending demand for skilled workers imposed by the knowledge-intensive economy.

INDEX WORDS: Higher education, Degree production, Knowledge-intensive economy, Bachelor's degrees, Master's degrees, Doctoral degrees, Public research universities, Production function, Seemingly unrelated regression, Double-log model

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FRANKLIN MAURICIO SAAVEDRA CAPELO

B.S.Ed., Universidad Central del Ecuador, Ecuador, 2004

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FRANKLIN MAURICIO SAAVEDRA CAPELO

Major Professor: James C. Hearn

Committee: Robert K. Toutkoushian
Sheila Slaughter
Libby V. Morris

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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DEDICATION

I dedicate this dissertation to the Lord Jesus Christ, my God, who has blessed me tremendously with a wonderful family, amazing friends, and outstanding professors. To my precious and loving wife, Catalina Calderón de Saavedra, without whose help and support I would have not been able to undertake and successfully complete the awesome experience of graduate school. To my cherished and treasured children, Nicole and Josué, whose love and prayers encourage me daily to endure and gain the right perspective. To my kind parents, Franklin Saavedra and María de Lourdes Capelo, who have always supported me with their unconditional love. And, to my home country, Ecuador, hoping that the spirit of research and analysis may overcome political irrationality.

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CHAPTER 1

INTRODUCTION

> By 2020, America will once again have the highest proportion of college graduates in the world (President Barack Obama: Address to a joint session of the U.S. Congress; February 24, 2009).

The study of degree production in higher education is significant for administrators and decision makers in colleges and universities, and, for policy makers at the state and national levels. From an administrator's perspective, colleges and universities strive to improve the graduation of their students by creating entire offices and units dedicated to this goal in an effort to fulfill their mission, improve their competitiveness, and respond to accountability concerns. Although attending college helps students develop in the social, psychological, and cognitive realms, students do not fully reap the benefits of a college education until the attainment of a degree, especially as it relates to earnings (Bill & Melinda Gates Foundation, 2009a; Institute for Higher education Policy [IHEP], 2005; Kelly, 2005; McMahon, 2009), as well as, other private benefits such as health and quality of life (IHEP, 2005; McMahon, 2009). In addition, given the knowledge-intensive economy that characterizes current times, students are not able to successfully compete in the labor market and/or pursue more advance education unless they attain a college degree. Hence, colleges and universities focus on degree production as one of the measures for institutional success.

From a statewide and from a national perspective, the study of degree production is extremely important because it is towards the states' and the nation's best interest for colleges and universities to graduate the students they enroll in order to benefit society in the form of reduced crime rates, increased community service, and increased quality of civic life and social cohesion (IHEP, 2005; McMahon, 2009). In addition, economic theory makes the case that degree production contributes to regional and national economic growth and to global competitiveness in that education serves as a proxy for the quality of a state's and the nation's labor force (Goldin & Katz, 2008; Leslie & Brinkman, 1988; McMahon, 2009). The contribution of higher education to labor quality is particularly important in the global economy considering that colleges and universities produce much of the highly skilled workforce responsible for a nation's research and innovation. From these, it has been established that the latter is clearly a major contributor to economic growth and global competitiveness (Gordon, 2002; Nelson, 1996). Gordon (2002), in particular, found a positive relationship between innovation, as represented in technological advances, and economic growth. Thus, degree production contributes not only to education but to the nation's well being overall.

Statement of the Problem

Given the importance of degree production, the problem rises for the United States specifically as it relates to economic growth, which supports social mobility, and, global competitiveness, which sustains the current standard of living in this nation. Estimates indicate that the knowledge-intensive economy's demand for skilled workers coupled with the looming retirement of the baby-boomers will generate millions of jobs in the U.S. that might go unfilled by its workers, not because of outsourcing, but rather due to the nation's potential shortage in supplying postsecondary graduates (Carnevale, Smith, & Strohl, 2010; Lumina Foundation for Education, 2006; Reindl, 2007). A most recent report released by the Georgetown University Center on Education and the Workforce, forecasts that unless there is a significant change in course today, there will be a shortage of 3 million workers in the U.S. by 2018; a yearly deficit of

300,000 college graduates (Carnevale et al., 2010). Moreover, the report points out that by 2018, 63% of total jobs will require some sort of postsecondary education and training. Hence, the main challenge to economic growth and development in the U.S. will not be outsourcing,[1] but rather shortness in supply of highly skilled workers via postsecondary education.

In addition, as it relates to global competitiveness, several countries have begun to overtake the U.S. in postsecondary attainment (Bill & Melinda Gates Foundation, 2009a, 2009b; National Center for Public Policy and Higher Education, 2005; Reindl, 2007; Wagner, 2006; Zumeta & Evans, 2010). Twenty years ago the U.S. was leading in the percentage of adults ages 25-34 with postsecondary education; today, the U.S. ranks tied for 10th within this particular age group (Bill & Melinda Gates Foundation, 2009b). Fewer than 40% of adults ages 25-34 hold a two-year or four-year degree in the U.S. (Miller Center Public Affairs – University of Virginia, 2010). Although this percentage for the U.S. has remained stable for decades, other industrialized countries have made significant increases in degree attainment in recent years (Bill & Melinda Gates Foundation, 2009a; Miller Center Public Affairs – University of Virginia, 2010). Hence, it has been estimated that by 2025, holding everything constant, there will be a shortage of 16 million undergraduate degrees to meet domestic workforce needs and keep up with leading nations in the percentage of adults with a college degree (Reindl, 2007).

As such, the nation's competitive advantage responsible for propelling the national economy and improving social mobility has began to slip away. For this reason, degree

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[1] Although outsourcing constitutes a threat to economic development and growth by losing jobs, the main problem the U.S. is facing is that demand for highly skilled workers is steadily growing faster than the supply. In addition, as it relates to outsourcing, McMahon (2009) points out that "U.S. jobs, mostly lower-skill but also those that can be handled over the Internet, are outsourced to Mexico, China, Vietnam, India, Taiwan, Indonesia, and Latin America" (p.22). And that "jobs lost from freer trade in industrialized economies are primarily middle-and low-skill manufacturing jobs in textiles and other manufacturing, and clerical jobs from car rentals to publishing that can be outsourced over the internet" (p.22). The result of this practice, however, is "fast-growing demands for higher-skilled persons in the country from which the outsourcing is occurring, and increases in the excess supply of persons with lesser skills" (p.22). This is the case for the United States.

production is becoming more and more a core policy issue for various higher education leaders and policy makers across the country, as well as, for organizations such as the U.S. Chamber of Commerce, the Lumina Foundation for Education, and the Bill and Melinda Gates Foundation, all of which are championing increasing the production of postsecondary degrees in the United States. Therefore, studying degree production in colleges and universities in the U.S. represents a significant contribution to individual, institutional, and societal success for this nation.

Purpose of the Study and Research Questions

This study examines the production of bachelor’s degrees, master’s degrees and doctoral degrees in public research universities in the United States by analyzing the association between departmental factors in academic units and the number of degrees conferred by each of these units taking into consideration quality and field of study. Herein, the focus is on the department as the unit of analysis due to its importance as the production unit within higher education. Departmental factors are defined as instructional type, size, and resources. Instructional type includes tenured/tenure track faculty, adjunct faculty, and graduate assistants; size is measured by total instructional full-time equivalent (FTE) and resources encompass the departments’ instructional expenditures and research expenditures. As such, the research questions for this study are as follows:

1. How are departmental factors in academic units such as instructional type (i.e. mix of tenured/tenure track faculty, adjunct faculty, and graduate assistants); size (i.e. total instructional FTE); and financial resources (i.e. instructional expenditures and research expenditures) associated with the production of bachelor’s degrees, master’s degrees, and doctoral degrees, taking into account quality and field of study?

2. What departmental factors (i.e. instructional type, size, and financial resources) in academic units achieve the greatest number of graduates taking into account quality and field of study?

3. How does the production of bachelor's degrees, master's degrees, and doctoral degrees vary across academic fields after holding constant quality and the respective departmental factors?

Examining the association between the dependent variables: number of bachelor's degrees, number of master's degrees, and number of doctoral degrees conferred by academic departments respectively, and, departmental factors in these units should improve our understanding of academic departments and, as such, better inform decision making and policy in response to the impending demand for highly skilled graduates in the current knowledge-intensive economy.

Significance of the Study and Contribution to the Field

The significance of this study and its contribution to the field of higher education is based on several fronts. First, contrary to employing a purely descriptive analysis by considering only the number of degrees produced and conducting comparative analysis, which is usually the norm when examining degree production in colleges and universities, this study employs a regression based statistical component that focuses on the factors of production while controlling for additional factors related to the production of degrees. Second, not many researchers have focused on degree production as the sole outcome of interest where the number of degrees produced has constituted the dependent variable. Those who have conducted statistical analysis of this sort have aggregated the data at either the state or institutional level, masking, as such, important findings at the departmental level. The advantage of this study is that academic departments, the heart of production within higher education, comprise the unit of analysis. Third, the literature on how degrees are produced treats the academic department somewhat like a "black box." Although most scholars agree the box is of great importance, there has been little scholarship that has attempted to break it open. Hence, this study constitutes a contribution to the field of higher education in that it explores this black box by examining the association between the aforementioned departmental factors in academic units and the number of degrees produced by each of these units for all three types (bachelor's degrees, master's degrees, and doctoral degrees). Finally, this study is significant and it represents a contribution due to its effort to control for quality and field of study throughout the analysis as demanded by the research questions.

Organization of the Study

Having introduced, in this chapter, the statement of the problem, the purpose of the study, its research questions, and the study's significance and contribution to the field of higher education, chapter two provides a review of literature related to production within higher education. In this same chapter, after pointing out areas where there remains a gap in the literature concerning the production of degrees, the conceptual framework for this study is presented and several hypotheses are elaborated. Chapter three explains and develops the research design by which the research questions and hypotheses are examined. This chapter includes a description of the method, the data, the general model, the specific equations, the variables, and the limitations of the study. The findings for the study are presented in chapter four while chapter five provides a summary of these findings together with conclusions for policy implications and recommendations for future research in order to better inform decision making and policy concerning the production of degrees.

CHAPTER 2

REVIEW OF THE LITERATURE

Degree production in higher education can be examined by analyzing the number of degrees awarded by type of institution (i.e. community colleges, four-year colleges, and research universities); by field of study (for example, science, technology, engineering, and mathematics, known as STEM fields); by level (i.e. bachelor's degrees, master's degrees, and doctoral degrees) and by region among others. Descriptive and comparative studies can then be conducted by considering the numbers of degrees awarded by level. An example of this type of analysis, found within the literature, includes a biannual study produced by the National Science Foundation (NSF) for STEM fields (National Science Board [NSB], 2008, 2010). A statistical component can be added to descriptive and comparative studies by focusing on a particular unit of analysis and examining significant factors related to the production of degrees via regression based analyses.

Units of analysis within higher education comprise the individual level (i.e. students, faculty, administrators, etc.), the institutional level (i.e. colleges and universities by type of institution), and the departmental level (i.e. academic departments usually grouped by fields of study and by type of institution). At the individual level, analysis related to degree production most commonly takes the form of retention and graduation studies (Adelman, 1999; Astin, 1977, 1993; Braxton &McClendon, 2002; Cabrera, Nora, & Castaneda, 1993; Pascarella & Terenzini, 1991; Tinto, 1993, 1997). This type of analysis represents the demand side of degree production and usually focuses on examining student characteristics, environmental variables, and school related variables as significant factors for students' retention and eventually for their graduation.

Statistical studies related to degree production on the supply side, that is, at the institutional or departmental levels are most commonly found within higher education production literature. This literature examines production in higher education from a microeconomics perspective by employing production and cost functions. A production function, which constitutes the basis for the conceptual framework in this study, represents the process by which colleges and universities transform inputs into outputs (Hopkins, 1990) while a cost function examines the cost of producing those outputs (Lewis & Dundar, 2001). From this perspective, taking into consideration the concept of microeconomics, which is the efficient allocation of limited resources among unlimited wants, production and cost functions are related in that the former defines the maximum output obtained from a combination of inputs while the latter determines the minimum cost to obtain a certain level of output. Hence, production functions and cost functions are different, yet, similar ways of analyzing the production phenomenon in higher education (Brinkman, 1990).

More specifically, within the production function concept, colleges and universities take students and faculty to produce instructional and research outputs (Paulsen & Toutkoushian, 2006) while cost functions examine both the cost of producing certain output and also the production of that output by focusing on economies of scale and scope (Lewis and Dundar, 2001). Economies of scale are obtained if the output increases to a greater extent than the cost when production is expanded (Dundar & Lewis, 1995; Toutkoushian, 1999). In other words, economies of scale are achieved in colleges and universities, for example, when the average cost of educating a student is reduced by increasing enrollment. Economies of scope are present when costs are reduced by producing outputs simultaneously (Dundar & Lewis, 1995; Toutkoushian, 1999).

The importance of examining production and cost functions within higher education, as it relates to the statement of the problem in this study, is that higher education administrators have very little knowledge concerning the relationship between expenditures and outputs in their institutions and believe that by increasing expenditures, outputs will also increase and better quality outputs will be obtained (Bowen, 1980; James & Neuberger, 1981). Hence, production and cost studies are important and helpful in providing a better understanding of this relationship. Moreover, policy and decision makers can be better informed by production and cost studies in regard to economies of scale and scope, which are alternate ways of reducing costs (Toutkoushian, 1999). In addition, production and cost studies can aid higher education administrators, policy makers, and decision makers by allowing them to conduct comparative studies related to production and cost to better evaluate their own institutions and systems (Toutkoushian, 1999). As such, by taking a microeconomics approach for the analysis of degree production, this study reviews production and cost function literature to guide the construction of the research design presented in chapter three.

This section begins by addressing the joint production issue, which is common within production literature. Then, production and cost function studies within higher education are reviewed. The former examines classic production function literature while the latter narrows in studies that have examined production in higher education via economies of scale and scope. Having explored this literature, studies that have focused on the production of college degrees and studies related to the research questions posed in chapter one are presented. The review of the literature in this chapter serves as a guide not only for the analysis, but also as support for the statistical models within the research design of this study, as well as the method employed. A brief segment is included after this review to point out a gap in the literature. This chapter ends by considering the conceptual framework and the elaboration of hypotheses for this study.

The Joint Production Function Issue

Prior to reviewing the various studies, it is important to address an issue that is common when analyzing production and cost in higher education: the joint production function. Simply put, this function constitutes producing several outputs jointly. The joint production function in higher education comprises examining the outputs of production, which for colleges and universities vary according to institutional type and mission statement. The mission of the majority of research universities in the U.S., the population of interest in this study, usually focuses on instruction, research, and public service as the most important outputs. From these, only instructional and research outputs have been examined within production and cost function studies; public service has not been considered in these studies due to lack of reliable data concerning this output (Lewis & Dundar, 2001; Olson, 1994). Instructional and research outputs are somewhat complex to analyze given their joint production, that is, faculty members produce these outputs jointly due to their involvement in both of these activities. However, several methods and approaches have been employed to address this issue; these are examined and discussed throughout this section. The present study draws on these methods and employs combinations of them in the research design section.

Production Function Studies

The literature on production function within higher education introduces two sets of studies: those that have examined instruction as a single production function and those that examined instruction and research as a joint production function.

Instruction as a Single Production Function

This particular set of literature guides the present study by pointing to the output and input variables that have been considered when measuring instructional productivity in higher education.

Wallhaus (1975) discussed the use of measuring instructional production from its simplest form by using student credit hours as an output and instructional cost as an input. In his analysis, Wallhaus pointed out some of the shortcomings of using this single measure as a proxy for productivity and the need to expand this measure more comprehensively. Gulko and Hussain (Gulko & Hussain, 1971, as cited in Hopkins 1990) used the concept of production function to build a more sophisticated model for measuring instructional productivity. The model included student enrollment as the output variable with faculty FTE, staff FTE and other university resources as the input variables. The model was developed at the departmental level with the intent to inform decision making for higher education administrators in regard to long-range planning. Oliver and Hopkins (1976) set out to evaluate instructional productivity via a more complex model that examined cohorts of students across time by focusing on the flow of students from enrollment to completion or dropout. In their unit cost model, instruction was measured by faculty-student ratios, that is, student enrollment as output and the number of teaching staff as input. Radner and Miller (1975) used a similar concept (faculty-student ratio and time) to estimate demand and supply for higher education in the United States.

A couple of points can be made from this set of literature in regard to guiding the present study. First, student school credit hours (Wallhaus, 1975) and/or student enrollment (Gulko & Hussain, 1971, as cited in Hopkins 1990; Oliver and Hopkins, 1976; Radner and Miller, 1975) have been employed as outputs when measuring instructional productivity. Second, these outputs have been modeled as a function of instructional FTE (Gulko & Hussain, 1971, as cited in Hopkins 1990; Oliver and Hopkins, 1976; Radner and Miller, 1975) and other university resources such as instructional expenditures (Wallhaus, 1975). These observations are important in that it is necessary at the outset to clearly identify the outputs and the inputs in a production function within higher education. As such, this study omits the use of students' enrollment, students' FTE, and students' credit hours as input variables in that these are outputs rather than inputs. Instead, this study focuses on instructional FTE and instructional expenditures as input measures to estimate the instructional outputs examined in this research (bachelor's degrees, master's degrees, and doctoral degrees).

Instruction and Research as a Join Production Function

Moving on into the second set, studies that have examined the joint production of instruction and research include those by Nervole (1972), Southwick (1969), Sengupta (1975), Olson (1994), and Gander (1995, 1999). This literature guides the present study by further clarifying the input and output variables of a higher education production function and by offering different approaches for addressing the joint production issue.

Nervole (1972) examined the joint production function conceptually via a Cartesian plane through which he specified areas where undergraduate education, graduate education, and research were complements and a wider area where these outputs were substitutes. Based on the area where the outputs were complements, he concluded that it was more efficient to produce these outputs in the same institution than in separate institutions.

Southwick (1969) examined production and cost relationships for 68 Land Grant Colleges for a period of seven years. Southwick modeled separate production functions via multiple regression analysis; one for each of the six inputs he considered important to examine.

These six input measures included administrative staff (total number of professional administrators), capital, library staff (total number of professional library staff), senior teaching staff (FTE), junior teaching staff (adjunct faculty and graduate students), and research staff (number of professional research personnel). For each of these six equations, the single input being modeled as the dependent variable was a function of a combination of different outputs: undergraduate students (measured by FTE), graduate students (measured by enrollment figures) and research (measured by funds from contracts and grants). Southwick conducted these six regressions for each of the seven years and compared coefficients across time; he then, added costs to the production equations in order to determine the cost of production. Hence, Southwick accounted for the joint production function by modeling separate equations for each of the inputs as a function of the outputs.

Sengupta (1975), working with cross-sectional data for 25 universities, divided the data into two groups based on a ratio of graduate to undergraduate enrollment and estimated production and cost functions. The latter was accomplished by regressing inputs as a function of outputs where the inputs and outputs where the same variables as those estimated by Southwick (1969). For the production function, Sengupta employed five different equations for each of the two groups. He focused on graduate enrollment and a y* variable as the outputs of interests. The latter consisted on the sum of the coefficient obtained from regressing undergraduate FTE into graduate enrollments plus undergraduate FTE. The inputs included instructional FTE (represented as the sum of senior faculty and teaching assistants) and professional library staff. Instructional FTE was significant in all of the equations while professional library staff was not significant in any of the equations. The equations were estimated using levels and also using logs for the input variables. Sengupta attempted to account for the joint production function by modeling the ratio of graduate to undergraduate enrollment (y*), which in a sense reflected a weight given the two major instructional outputs.

Olson (1994), using a sample of 200 universities, explored instructional and research productivity accounting for the joint production function by: 1) modeling, similar to Southwick (1969), the input faculty FTE as a function of three major outputs (undergraduate students' FTE, graduate students' FTE, and research production measured by number of articles published) and 2) estimating separate equations; one for each of the outputs as a function of the inputs and other independent variables, mainly, institutional controls. Overall, he found a significant and positive relationship between the input (faculty FTE) and the outputs (undergraduate FTE, graduate FTE, and research).

Gander (1995), using three years of data for 31 academic departments in a single university explored the relationships among research, instruction, and internal department structure through the joint production of research and instruction. Gander estimated three equations, one for each output, by using double logs. The outputs included instructional productivity, measured by student credit hours (undergraduate and graduate school credit hours were lumped together by using a weight of 1 for the former and 3 for the latter); research, measured by research expenditures; and research intensity, measured by the ratio of research to teaching (research expenditures were divided by student school credit hours). The inputs for each of these equations were faculty (measured by number of full-time tenured/tenure track faculty), which Gander considered to be the key factor input; the size of the department (measured by total student enrollment); and dummy variables to account for fields of study and for time in that he had three years of data. Gander acknowledged the joint production issue and responded to it by estimating the first two equations (instruction and research) simultaneously using the seemingly unrelated regression (SUR) method and by estimating the ratio of research to instruction for the third equation (research intensity). Overall, Gander's analysis reported that the coefficient for faculty was positive and significant in all three outputs. The coefficient for student enrollment was also significant in all three outputs, but it was positive only for the instructional output.

In a subsequent analysis, Gander (1999), using cross-sectional data on 523 institutions, employed a joint production function by estimating three different equations simultaneously. Each of the equations corresponded to a different output. The outputs included undergraduate instruction (students' enrollment FTE), graduate instruction (students' enrollment FTE), and research (research expenditures). Each of the outputs was estimated as a function of total number of regular female faculty, total number of regular male faculty, number of administrative staff, and a set of control variables. All of the variables (outputs and inputs), except for the dummies, were logged. Thus, Gander interpreted the results in term of elasticity. Overall, the coefficients for male faculty were significant and positive for all three outputs while the coefficients for female faculty were significant and positive for the teaching outputs only. In addition, as compared to male faculty, female faculty showed a lower marginal productivity in undergraduate instruction but no gender differences were found in graduate instruction. As far the coefficient for administrative staff, it was not significant for undergraduate instruction, but it had a significant and positive effect on graduate instruction and research activity. It can be seen from Gander's studies (1995, 1999) that he responded to the joint production issue by using two different methods: 1) modeling a ratio of two given outputs as the dependent variable and 2) estimating separate equations (one for each output) simultaneously via the SUR method.

This second set of literature supports the importance of including faculty FTE as the main input for estimating instructional production and offers different methods for addressing the joint production issue: 1) regressing the inputs as a function of the outputs (Southwick, 1969; Olson, 1994); 2) modeling separate equations; one for each of the outputs (Olson, 1994); 3) estimating simultaneously, through the SUR method, separate equations that were constructed for each of the outputs (Gander 1995, 1999); and 4) using a ratio between two major outputs as the dependent variable (Gander, 1995; Sengupta, 1975). The latter, although it represents a clever way of estimating output substitution, is limited to two outputs in that it is a ratio. Following the work of Olson (1994) and Gander (1995, 1999), this study addresses the joint production issue by employing the second and third methods. Besides the methods presented in this segment, there are additional approaches that have been employed to account for the joint production issue. These are reviewed in the next segment and some of them are also employed in this study to further account for this issue.

Additional Approaches for Addressing the Joint Production Issue

The production and cost function literature offers additional alternatives for addressing the joint production issue. Given that professors distribute their academic contract obligations mainly between instruction and research, one can explore institutional and departmental production in light of the joint production issue by separating instructional outputs from research outputs via faculty members' time allocation and/or by assigning weights to the different outputs and adjusting for the differences.

O'Neill (1971), based on information provided by previous studies, established a cost ratio of 3 to 1 for graduate to undergraduate credit hours and a cost ratio of 1.5 to 1 for upper to lower division credit hours. She then employed these weights on students' credit hours and determined their cost at each level based on the percent distribution assigned for instructional costs out of the total yearly expenditures of colleges and universities in the United States. Applying this methodology she was able to separate instructional outputs to examine costs differentials, credit hour production, and total student instructional cost on historical data that covered a period of thirty-seven years.

James (1978), examining faculty time allocation data noticed an increase in the percentage assigned for research by faculty. She argued that this increase had resulted in faculty shifting their time from undergraduate instruction to research within the expenditures category assigned for instruction and departmental research. James estimated that faculty time allocation for research had increased from 20% in 1953 to 40% in 1967. Given this estimate, she pointed out that under the expenditures category assigned for instruction and departmental research 40% were used for non-instructional purposes. Focusing on the instructional share, James employed the weights used by O'Neill (1971) for students' credit hours at the different levels and recalculated O'Neill's estimates by adjusting for this 40% difference. Hence, based on faculty time allocation data, James was able to disaggregate the aforementioned category and discover that contrary to O'Neill's findings there was a lower true cost for undergraduate instruction and a higher rate of productivity.

Hopkins and Massy (1981), with the intent to estimate the direct and indirect costs of instruction, built a theoretical model that depended on faculty members' time allocation. The model consisted in distributing instructional FTE among five major categories: classroom teaching, teaching outside the classroom, joint teaching and research, pure research, and administration. The distribution was based on faculty members' time allocation. Although

Hopkins and Massy's (1981) model made theoretical sense, its usefulness was based upon having at hand faculty members' time allocation data.

Becker (1975) also proposed a theoretical model to account for a faculty member's individual behavior through a utility function. In his model, utility was maximized as a function of teaching, research, and leisure constrained by time (faculty time allocation). The joint production was represented by the faculty member's time spent on either teaching or research affecting the other activity in some way. A similar approach has been employed, in more recent times, by Leslie, Oaxaca, and Rhoades (1999) who applied a utility function to a sample of 417 faculty members representative of 11 universities from the Association of American Universities (AAU). Leslie et al.'s data set constitutes, perhaps, the richest and most complete data set ever collected on faculty time allocation at AAU universities. The variables in this data set included faculty time allocation on instruction, research, and service. Each of these groupings was further disaggregated into faculty member's time allocation to the various activities within each category. Under instruction, for example, variables such as time allocation to undergraduate and graduate instruction were ready available. The research category was also very helpful in that it disaggregated faculty member's time allocation into time spent on departmental research versus externally supported research. Hence, this data set allowed the researchers to separate instructional, research, and service outputs and estimate a percent allocation of faculty members' time. Based on these data, Leslie et al. (1999) determined that on average faculty spent 42.4% of their time in instruction, 32.3% in research, and 20.2% in service.

This and the previous segment provide information on the several methods and approaches that have been employed to address the joint production issue. The present study draws on these methods and employs a combination of them in the research design section to address this issue. First, following the work of Hopkins and Massy (1981) and Leslie et al. (1999), this study disaggregates faculty time allocation between instruction and nonteaching activities and focuses on the former. Then, borrowing on Olson's (1994) and Gander's (1995, 1999) approach, this study models a separate equation for each of the outputs (i.e. bachelor's degrees, master's degrees, and doctoral degrees) and also estimates them simultaneously using the SUR method.

Cost Function Studies

To expand on the relationship between production and cost functions, which was explained in the beginning of this chapter, cost functions focus on production and productivity by estimating average and marginal costs and by examining the efficiency of producing an output given the resources available, that is, economies of scale and scope (Brinkman, 1990, 2000, 2006; Lewis & Dundar, 2001). To accomplish these tasks, cost functions rely on the production function of that output, which constitutes its production technology (Brinkman, 1990, 2000, 2006; Lewis & Dundar, 2001). In other words, to estimate the appropriate average or marginal cost of an output and to examine whether cost efficiencies can be improved via economies of scale and/or are present via economies of scope, cost functions need to determine the specific inputs that go into the production process of that output in order to attach a cost to these inputs and estimate the aforementioned cost products. Hence, higher education cost function literature is significant for the topic of this present study in that it: 1) analyzes the inputs and outputs of production in research universities; 2) aids concerning the proxies that have been employed to measure inputs and outputs; and 3) brings to the forefront different issues that need to be considered when modeling production within higher education.

Traditionally, cost studies in higher education have focused on undergraduate instruction and on average unit costs by taking direct instructional cost and dividing it by the number of credit hours generated or by student enrollment via FTE (Brinkman, 1990; Toutkoushian, 1999). A more sophisticated analysis has constituted estimating a cost function to compute average and marginal costs where the latter represents the change on total cost associated with an additional unit of output (Brinkman, 1990, 2000, 2006). However, single unit cost analysis, that is, undergraduate instruction only, has been criticized for failing to take into account the additional outputs of higher education and the multiproduct nature of production within this industry, that is, the joint production issue (James, 1978; Lewis & Dundar, 2001). James (1978), for example, has argued that single output models, such as estimating the cost of undergraduate instruction via credit hours or student enrollment (FTE), overestimates its true cost by not including in the model graduate instruction and research.

Hence, since the late 1980s and especially during the 1990s a new set of cost studies emerged in the U.S. to account for the multiproduct function of research universities (Cohn, Rhine, & Santos, 1989; de Groot, McMahon, & Volkein, 1991; Dundar & Lewis, 1995; Koshal & Koshal, 1999; Nelson & Hevert, 1992; Robst, 2001; Toutkoushian, 1999). While all of these studies have focused on economies of scale and economies of scope, some of them have also examined marginal costs. All of these studies conducted their analysis at the institutional level with the exception of Nelson and Hevert (1992) and Dundar and Lewis (1995) who conducted their analysis at the departmental level. Nelson and Hevert concentrated on a single university while Dundar and Lewis examined departmental data across 18 public research universities.

For the most part, the methodology employed by these cost function studies follows the work of Baumol, Panzar, and Willig (1982) and Mayo (1984) who managed to account for multiproduct production in their econometric models. The equations in higher education cost studies, basically, estimate the dependent variable total cost as a function of the various higher education outputs and some control variables to account, statistically, for confounding effects. Total costs include all of the costs for the production of teaching and research where the costs for faculty and support and administrative staff are considered the main inputs (de Groot et al.,1991; Dundar & Lewis, 1995; Lewis & Dundar, 2001). The latter, is in line with the production function studies where faculty FTE has continuously been considered the most important input in estimating instructional and research productivity. Although there are no standardized measures for inputs or outputs, all of the cost studies in higher education have employed either student credit hours or student FTE as the instructional output and number of publications or research expenditures as the research output; de Groot et al. (1991) also examined degrees earned as instructional output and Nelson and Hevert (1992) examined percentage of faculty time devoted to research as output. The use of these proxies to measure instructional and research outputs is also in line with the production function studies where similar variables have been employed to measure instruction and/or research production. Overall, cost function studies find mixed results in regard to marginal costs, economies of scale and economies of scope. In addition to joint production or the multiproduct nature of higher education, cost studies focus on few other issues that are important to consider when modeling cost or production functions in higher education, mainly: quality, unit of analysis, and class size. This study, accounts for these issues in the research design.

Quality

Dundar and Lewis (1995) and Lewis and Dundar (2001) emphasize the importance of including a variable to control for quality within the econometric models, and, at the same time point out the difficulty of finding appropriate measures for quality and quantifying them in order to include them within the various equations. The issue of quality for the cost studies lies in the validity of their estimates when measuring production and efficiency. For example, different types of institutions might report different costs for their outputs when estimating marginal costs; before drawing conclusions based on a comparative analysis of these marginal costs, one needs to consider whether these results are due to quality differentials. The same issue is present with economies of scale and scope. For the former, for example, reducing costs by enrolling more students would represent efficiency in production; however, would efficiency still be present if quality of education is affected negatively by increasing enrollments? In spite of its importance, once again, it is extremely complicated to find adequate measures for quality; hence, this inability constitutes the most pervasive limitation for the cost studies.

Given the difficulty of adding an adequate control for quality, many of the cost studies, as well as, the production function studies have not included this variable in their equations. Focusing on the former, some have attempted to control for quality by including a related proxy according to data availability (de Groot et al., 1991; Dundar & Lewis, 1995; Koshal & Koshal, 1999; Tierney, 1980) while others have simply omitted its inclusion and/or justified for its omission due to its inability (Cohn et al., 1989; Nelson & Hevert, 1992; Robst, 2001; Toutkoushian, 1999). Although Cohn et al. (1989) and Nelson and Hevert (1992) did not specifically include a quality variable in their equations, they argued that quality was controlled for by separating the analysis between private and public universities for the former and disaggregating undergraduate credit hours into lower and upper division for the latter. Furthermore, Nelson and Hevert pointed out that the inclusion of their class size variable was able to capture differences in education technology across departments. Class size, has been considered a measure of quality by James (1978, 1990); James and Neuberger (1981); and Tierney (1980), who assume higher quality for smaller class size.

Concerning those who specifically included a quality variable, student academic ability (Koshal & Koshal, 1999; Tierney, 1980) and reputational ratings (de Groot et al., 1991; Dundar & Lewis, 1995) have been employed respectively. Koshal and Koshal (1999) arguing, based on Koshal and Koshal (1995), that Scholastic Aptitude Test (SAT) scores and *US News* and *World Report* quality index for colleges had generated similar results in regression analysis, used the average total scores on the SAT of entering freshmen as a measure of quality for their analysis at the institutional level and discovered that quality had a significant positive effect on total costs. Tierney (1980), in his analysis at the departmental level, determined the quality of each of the academic units based upon "the selectivity of the institution at which the department was located" (p.460). That is, he assigned a quality score to each academic department based on the institutional score. Selectivity was measured by average academic ability of entering freshmen; he too found a significant positive effect for quality on departmental costs. Moreover, Tierney (1980) suggested that quality could be measured via student-faculty ratios and average faculty salaries where higher quality institutions would have lower student-faculty ratios and higher average faculty salaries. De Groot et al. (1991) using peer ratings as a measured for quality found that although the quality variable was significant in their analysis, it did not make a difference in the overall results of the model. Lastly, Dundar and Lewis (1995) controlled for quality by using measures from the 1982 *Assessment of Research-Doctorate Programs in the United States* put forth by the National Research Council. The researchers found that their measure for quality was not significant and explained that this was the case due to the homogeneity of their sample. Hence, from this explanation, it can be inferred and argued that if including an appropriate measure for quality represents a difficulty due to lack of having an appropriate variable, one could do without as long as the sample is homogenous.

Unit of Analysis

A second issue presented by the higher education cost studies is the importance of focusing on academic departments as the unit of analysis rather than on institutions (Dundar and Lewis, 1995; Lewis and Dundar, 2001, Nelson & Hevert, 1992; Tierney, 1980). Proponents of this argument support their view by pointing out that analysis at the institutional level is not able to account for differences in the production technology of the various academic disciplines. Not accounting for these differences represents an issue for the cost studies in that different fields of study might report different costs, which are masked when aggregated and estimated at the institutional level.

There are three salient studies from the higher education cost functions literature that have focused on estimating cost at the departmental level: Tierney (1980), Nelson and Hevert (1992), and Dundar and Lewis (1995). The former examined seven academic departments across 24 institutions for a period of four years. The information of each department was pooled across the four years and separate cost equations were performed for each department. Nelson and Hevert (1992) on the other hand, focused on a single institution and were able to capture differences across departments by including in their model average class size for each department and a dummy variable indicating the department's involvement in laboratory classes.

Finally, Dundar and Lewis (1995) accounted for departmental differences by estimating a cost equation separately for three fields of study on cross-sectional data. The fields included the social sciences, the physical sciences, and engineering sciences. In each of these fields, the researchers added department-specific dummy variables to account for departmental differences within each field. Hence, either running separate regressions for each field and/or department or adding control or dummy variables to the general model accounts for departmental differences in production; this study employs the latter.

Class Size

Nelson and Hevert (1992) have argued for the inclusion of class size as a control variable within cost functions. The obvious reason to control for this variable is that costs might increase as average class size gets smaller. In their analysis, Nelson and Hevert concluded that cost functions appeared to bias upward the estimates by failing to include such control. Koshal and Koshal (1999) in their model at the institutional level found that class size had a significant impact on total cost; overall, an average increase in class size was related to a decrease in cost. Although this present study is not so much interested in costs but rather in degree production, it is important to take into consideration the various control variables employed by the costs studies due to the existent relationship between cost and production functions. In addition, James (1978, 1990), James and Neuberger (1981), and Tierney (1980) have mentioned class size as a possible control variable for quality where higher quality would be represented by smaller class size.

Degree Production Studies

Few researchers have focused on the production of higher education degrees in the U.S. as the outcome of interest (Bound & Turner, 2007; Breneman, 1970, 1976; Dolan & Schmidt, 1994; Rhodes & Southwick, 1993; Titus, 2009a, 2009b). From these, Breneman (1970, 1976) examined the production of Ph.D. degrees at the departmental level in a single institution while Dolan and Schmidt (1994), by examining the number of alumni who later received Ph.D.s, M.D.s, or J.D.s, analyzed the production of private baccalaureate schools at the institutional level. At this same level of analysis (institutional), Rhoades and Southwick (1993) focused on public and private research universities to examine and compare their efficiency in producing higher education degrees, enrollments, and research. Bound and Turner (2007) and Titus (2009a, 2009b), on the other hand, examined the production of bachelor's degrees by focusing on states as the unit of analysis. All of these studies employed a production function perspective in their models (input-output relationship) and found that financial resources had a significant and positive effect on the production of degrees,[2] which supports the inclusion of financial variables within a model when examining degree production. Additional factors of production included in the models of the various studies reported different results in regard to their significance for the production of degrees. This segment explores these different factors.

Breneman (1970), in his production function model of 28 departments at a single university, estimated the number of Ph.D.s produced at each department as a function of number of master's degrees produced at each department,[3] number of FTE professors, number of teaching assistant positions, number of research assistant positions, number of fellowships, number of male Ph.D. students, and a quality variable that ranked each department according to the *Cartter Report*. All of the variables in the equation were weighted by total graduate enrollment in each department. Teaching and research assistant positions and fellowships were considered to be the financial support variables. In his analysis, Breneman found that only number of master's degrees produced, number of research assistant positions, and number of fellowships were significant. The former had a negative effect while the latter two had a positive effect on Ph.D. production. Quality had no significant effect.

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[2] Rhoades and Southwick (1993) focused on the efficiency of producing degrees rather than on the factors associated with degree production. From their perspective, "a university *may* be termed efficient if the relative performance ratio calculated for it is one and no inefficiency-related slack on individual inputs and outputs occurs" (p.150). Hence, their findings need to be examined from this efficiency perspective and should not be compared to the findings of the other studies given that their focus is somewhat different.

[3] Number of master's degrees produced at each department was included as an estimation technique in order to separate the graduate enrollment data between master's and Ph.D.s.

Dolan and Schmidt (1994) examined production across 361 private baccalaureate schools by focusing on the number of alumni who later had received a Ph.D., M.D., or a J.D. degree. They modeled three equations simultaneously: one for the aforementioned output, a second equation for students' quality, and the third equation for faculty members' quality. The former, being the output of interest was a function of students' quality (SAT scores of entering freshmen), faculty quality (average salary at the associate professor rank), capital (book value of capital stock), academic support outlay, administrative support outlay, research support outlay, faculty student ratio, instructor student ratio, undergraduate specialization ratio, four different curricular indices, percentage of male students, percentage of undergraduates who were business majors, percentage of undergraduates who were engineer majors, and percentage of undergraduates who were education majors. Results showed that faculty quality, academic expenditures, faculty student ratio, and percentage of male students had a strong statistical significance (p =.01) and a positive effect while student quality and one of the indices for curriculum had a mild statistical significance (p =.05) and a positive effect. Moreover, the percentage of undergraduates who were business and engineer majors had a strong statistical significance (p =.01) and a negative effect on the institution's production of PhD/Md/JD alumni. Overall, Dolan and Schmidt concluded that quality students and quality faculty supported by academic outlay were the major drivers of educational production and that the picture that emerged was the traditional recipe of undergraduate education: "a relatively high ratio of quality faculty to good students in a facilitating environment reflected by academic expenditure" (p.204).

Rhodes and Southwick (1993), focusing on 160 research universities compared the relative efficiency of public and private universities. Efficiency studies compare the outputs of production within a certain group by taking into consideration the inputs used by each institution for the production of those outputs. Rhodes and Southwick concentrated on six measures of higher education output (undergraduate enrollment, graduate enrollment, bachelor's degrees awarded, master's degrees awarded, doctoral degrees awarded, and research funds secured) based on five input measures: the number of full professors, the number of associate professors, the number of assistant professors and other teachers, the dollars spent annually on maintenance, and the dollars spent annually on library activities. Overall, they found that public universities were less efficient than privates, competition (having other universities in the same state) and size (having a large number of FTE students) had a positive effect on efficiency for both type of universities while state appropriation had a negative effect for publics. Quality, as measured by students' academic ability and faculty average salary, had no effect for both sectors.

Employing a different unit of analysis from the preceding, Bound and Turner (2007), and Titus (2009a, 2009b) have focused on the production of bachelor's degrees by aggregating institutions at the state level. Bound and Turner, who conducted a panel data regression analysis on the production of BA (undergraduate) degrees conferred, found that resources had a significant and large effect on degree production at this level. More specifically, they found that a reduction in resources per student via state appropriation due to increases in cohort size had a significant negative effect on the production of BA degrees conferred at the state level. This effect was labeled as the *crowding out* effect.

Titus (2009a, 2009b) used annual state-level panel data for both of his studies. Titus (2009a) found that enrollment overall had a significant positive effect on the production of bachelor degrees at the state level. However, increases in freshmen full-time enrollment had a significant negative effect. He attributed this finding to the *crowding out* effect as described in

Bound and Turner’s study. Moreover, he observed that need-based financial aid had a significant negative effect in the inefficiency of bachelor’s degree production, which suggested that need-based financial aid could have a significant positive effect in this output. Titus (2009b) regressed the number of bachelor’s degrees awarded per undergraduate enrollment in higher education institutions within a state on several financial variables related to state higher education policy. In his analysis, Titus found that increases in tuition at four-year public colleges or universities had no effect on the production of bachelor’s degrees; the same was the case for state nonneed-based financial aid. However, state need-based aid financial aid and state appropriations for higher education, including spending for private colleges and universities, had a significant positive effect on bachelor’s degree production within a state.

Additional Studies Related to the Research Questions

Additional studies related to the research questions in chapter one include those of Hasbrouck (1997), Zhang (2009), Ryan (2004), Ehrenberg and Zhang (2005), Zhang and Ehrenberg (2006), Leslie et al. (1999), and Volk, Slaughter, and Thomas (2001). The first three studies focused on the relationship between resources and output in higher education at the institutional level. Hasbrouck (1997) and Zhang (2009) found that variations in universities’ revenue sources accounted for variations in their outputs. Specifically, Zhang (2009) showed a significant positive relation between revenues from state appropriations and graduation rates. A similar finding was reported by Ryan (2004) who found a significant and positive relationship between graduation rates and both instructional and academic support expenditures per FTE student.

Ehrenberg and Zhang (2005) and Zhang and Ehrenberg (2006) focused on the institutional effect of faculty employment on university output. The former study employing panel data at the institutional level, found that increases in the total number of faculty at the institution was associated with higher graduation rates. However, increases in either the percentage of part-time faculty or non-tenure track full-time faculty were associated with a reduction in graduation rates. On a subsequent study, Zhang and Ehrenberg (2006) reported that increasing the number of part-time faculty had a positive effect on an institution’s external research expenditures and suggested that substituting full-time non tenure track for tenured and tenure track faculty had a negative effect on an institutions’ external research funding.

The study of Leslie et al. (1999) focused on examining faculty time allocation at the departmental level. In their analysis, they discover that on average faculty spent more time on instruction than on research (43% versus 31% respectively). However, faculty with external grant and contract funding spent a smaller proportion of their time on instruction and a larger proportion on research and service. Finally, the study of Volk et al. (2001), related to resource allocation, is informative due to some of the variables employed in their model. First, in their measure of departmental quality, they used two proxy measures: external dollars in grants and a quality score assigned to each department by the 1992 University-Wide Quality Review Committee. Second, their study argued that among the significant factors that had a positive relationship to internal resource allocation was closeness of the academic department to the market. As such, they used three proxy measures to examine such effect: student exit salary, initial salary of assistant professors, and grant and contract dollars generated by the various departments. Hence, grant and contract dollars was used as a proxy to measure both quality and closeness to the market.

Gap in the Literature

As already indicated, only few researchers have focused on degree production as the outcome of interest where the number of degrees produced represents the dependent variable. As seen above, out of those who have focused on such outcome, only Breneman (1970, 1976) conducted his analysis at the departmental level; all others conducted their research by aggregating data either at the institutional or state level. Although Breneman focused on academic departments as the unit of analysis, his research was limited to the production of doctoral degrees and the results were representative of a single university only. Hence, although the literature is very instructive on many points, there remains a gap concerning analysis that has specifically focused on the production of degrees as the outcome of interest at the departmental level on several universities by considering all three types of degrees (bachelor's degrees, master's degrees, and doctoral degrees) while at the same time controlling for quality and field of study. As such this study fills this gap and contributes to the literature by doing just that.

Conceptual Framework

To better understand the behavior of colleges and universities, this study employs the concept of production function (Hopkins, 1990), as already explained within the literature review, together with utility maximization theory (Garvin, 1980; Hopkins & Massy, 1981; James, 1978, 1983, 1990; James & Neuberger, 1981; Massy, 1996, 2003, 2004; Melguizo & Strober, 2007) and academic capitalism theory (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004). This section describes the theories and, through the elaboration of hypotheses, explains the way these theories relate to the topic and the research questions of this study. Given that the concept of production function has already been included in the literature review, it is not mentioned in this section but it is referred to in the elaboration of the respective hypotheses.

Utility Maximization

Utility maximization, as it applies to non-profit colleges and universities uses basic microeconomic principles to explain the behavior of colleges and universities and their departments. The theory basically emphasizes that colleges and universities and their academic departments prefer certain activities among others and exercise those preferences in their behavior. Just like market organizations maximize profit, non-profit organizations maximize value or utility according to the mission and preferences of the organization. The theory explains that academic departments distribute their resources in such a way so as to maximize the utility and value of their tenured/tenure track faculty members. High utility activities for this type of faculty members, according to the theory, include first and foremost research and low teaching loads followed by graduate instruction, student quality, and small graduate courses. The theory supports these activities as high utility based on the labor market for faculty members and faculty members' reward structure (both of which emphasize the importance of research production) and surveys of faculty members time allocation (the researchers indicate that faculty members allocate most of their time towards research and graduate instruction and less of their time towards undergraduate instruction). Hence, according to the theory, tenured/tenure track faculty members are more interested in research than in instruction, and, within instruction, they favor graduate production above undergraduate production (Garvin, 1980; Hopkins & Massy, 1981; James, 1983, 1990; James & Neuberger, 1981; Massy, 1996, 2003, 2004; Melguizo & Strober, 2007).

The emphasis on research as the most important activity for tenured/tenure track faculty members is encouraged by universities, especially research universities. This type of universities creates incentives, via prestige maximization and their reward structure, for tenured/tenure track faculty to focus on research rather than on teaching. This situation, in turn, results in a push for research universities to increase teaching via adjunct faculty and teaching assistants (Melguizo & Strober, 2007).

Academic Capitalism

Given that we live in a knowledge-intensive economy, academic capitalism explains the process by which colleges and universities are integrating into this new economy. The theory indicates that this integration is occurring through a behavioral change on the part of the higher education community where the members thereof (faculty, administrators, academic professionals, and students) form networks within and between the public and private sectors in order to market knowledge and gain profit from it. As such, higher education institutions are seen as marketers who capitalize on their captive market, students, offering them various services and products. Faculty, administrators, academic professionals, and students are seen as interested in knowledge in order profit from it. This investing, marketing, and consumption behavior creates the new academic capitalist knowledge/learning regime. This new regime, which is interested in the privatization of knowledge and profit, is compared to the traditional public good knowledge/learning regime, which places an emphasis on knowledge for the sake of knowledge, that is, as a public good to which citizens have access (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004).

Academic capitalism is appropriate for the topic of this study in that the theory explains that academic departments participate in the new regime and embrace the market seeking to increase revenues through both education-oriented activities and by competing intensely for federal contracts and grants. The former, include the increase in undergraduate credit hours by offering more attractive programs related to the new economy, summer programs, master professional programs associated to the market in industry, and linking students to potential employers in industry. Hence, the theory of academic capitalism offers explaining power for the increased production of bachelor's degrees and master's degrees in areas that are near the market and also for doctoral degrees as colleges and universities increase funding for graduate students by competing for contracts and grants in the federal research market (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004).

Elaboration of Hypotheses

As previously indicated, the analysis of this study is framed theoretically by the microeconomics concept of a production function together with the theories explained above. From a production function perspective and taking into consideration its fundamental axiom of production, it is expected that increasing the number of inputs in a production process yields a larger number of outputs subject to the law of marginal diminishing returns. Hence,

Hypothesis 1: An increase in the amount of inputs in the production process of degrees should yield an increase in the number of degrees produced controlling for quality.

Moreover, the production function process encompasses the technology of production where a greater number of outputs are obtained via a higher quality production process. Hence, quantity and quality of inputs determine the production of a given output. The basic inputs of production within higher education include instructional faculty. For this study, tenured/tenure track faculty are viewed as a higher quality production process as compared to the other instructional types (i.e. adjunct faculty and graduate assistants) in that the former are supposed to have greater skills, academic preparation, knowledge, and experience than the latter. Thus, a higher percentage of tenured/tenure track faculty involved in instruction within a department should have a significant positive effect on degree production overall. However, utility maximization theory argues that tenured/tenure track faculty prefer research and to a certain extent graduate production rather than undergraduate production. As such, one can infer from this particular theory that academic departments distribute their adjunct faculty and graduate assistants mainly towards the production of undergraduate degrees leaving the majority of tenured/tenure track faculty for the production of research and degree production at the graduate level. Hence,

> Hypothesis 2: Tenured/tenure track faculty involved in instruction at an academic department might actually produce fewer bachelor's degrees than the other instructional types (i.e. adjunct faculty and graduate assistants).

And,

> Hypothesis 3: Tenured/tenure track faculty involved in instruction at an academic department should produce more master's degrees and doctoral degrees than the other instructional types (i.e. adjunct faculty involved in instruction for producing both master's degrees and doctoral degrees and graduate assistants involved in instruction for producing master's degrees).[4]

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[4] While adjunct faculty are in many cases involved in instruction for the production of all three types of degrees (i.e. bachelor's degrees, master's degrees, and doctoral degrees), graduate assistants are mainly involved in instruction for the production of bachelor's degrees and at times also in the production of master's degrees.

In addition, the theory of academic capitalism offers explaining power for the production of: 1) bachelor's degrees and master's degrees in areas close to the market in accordance with the economy and 2) doctoral degrees in areas close to the federal research market. That is,

> Hypothesis 4: Fields of study closer to the market should be able to generate more bachelor's degrees and master's degrees due to the attractiveness of their programs in relation to the knowledge-intensive economy.

And,

> Hypothesis 5: Fields of study closer to the federal research market should be able to generate more doctoral degrees than other fields due to the emphasis academic departments place in competing for contracts and grants in such market.

Also, given the emphasis on academic departments competing in federal research markets for contracts and grants:

> Hypothesis 6: Funding from contracts and grants should have a significant and positive effect on the production of doctoral degrees due to the financial support that these funds provide for graduate students.

CHAPTER 3

RESEARCH DESIGN

The purpose of this study is to examine degree production in public research universities in the United States by analyzing the association between departmental factors in academic units and the number of degrees conferred by these units taking into consideration quality and field of study. As such, this study explores the three research questions introduced in chapter one and the six hypotheses presented in the previous chapter. To answer the research questions and examine the hypotheses, in this chapter, this study elaborates and presents the respective research design for a systematic analysis of the aforementioned.

This chapter begins by explaining the way the joint production issue is addressed in this study. Following this explanation, the method of analysis is introduced. Having introduced the method, this study refers to the data analyzed and explains the general model and specific equations estimated from this model. Subsequently, each of the variables employed in the equations are described and additional equations estimated in chapter four are discussed. The chapter ends with a section explaining the various limitations of the analysis.

Addressing the Joint Production Issue

This study addresses the joint production issue, as explained in the previous chapter, by applying a combination of the approaches discussed in the literature review. First, similar to Hopkins and Massy (1981) and Leslie et al. (1999), this study examines faculty members' time allocation between instruction and nonteaching activities and focuses on the former as the main input for degree production, separating as such, instructional input from research and/or service input. This separation is possible in that when collecting the data, institutions were asked to provide total faculty FTE and to "identify on a case-by-case basis those faculty who [were] contractually obligated to do something other than teach" (Middaugh, 2001, p. 101). Hence, the data set provides three variables for faculty FTE: total FTE; instructional FTE; and FTE assigned to nonteaching activities, which usually includes research and/or service. This study focuses on instructional FTE.

Furthermore, following Olson's (1994) approach to the joint production issue, as previously explained, a single equation is established for each of the instructional outputs (i.e. bachelor's degrees, master's degrees, and doctoral degrees) where each of these outputs is a function of the various inputs as indicated below under the general model for degree production in equation (1). Subsequently, building on Gander's (1995, 1999) approach to the joint production issue, the three equations are estimated simultaneously via the multivariate seemingly unrelated regression (SUR) method. The respective analysis, as explained below, is conducted to determine the preferred estimation method between equation-by-equation estimation via Ordinary Least Squares (OLS) and simultaneous estimation via SUR.

Method

This study explores both multiple regression analysis, for the estimation of the different single equations, and the SUR method, for the simultaneous estimation of these equations. The former uses the OLS estimator while the latter employs Feasible Generalized Least Squares (FGLS) estimation. The advantage of the latter over the former is to improve the efficiency of the parameter estimates by accounting for correlated errors across equations when estimating them simultaneously (Cameron & Trivedi, 2009; Green, 2008; Wooldridge, 2002; Zellner, 1962).

The general model for OLS expressed in terms of the conditional mean of the outcome and its explanatory variables is

$$E(y_i \mid x_{i1}, \ldots, x_{ik}) = \beta_1 x_{i1} + \ldots + \beta_K x_{iK}, \qquad i = 1, \ldots, N.$$

This model, in terms of y_i is represented as:

$$y_i = \beta_1 x_{i1} + \ldots + \beta_K x_{iK} + \varepsilon_i = \mathrm{x}_i \beta + \varepsilon_i$$

and employing matrix algebra can be written as:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon},$$

where

- $\mathbf{y} = (y_i)$ is a 1 x N vector
- $\mathbf{X} = (x_{i1} + \ldots + x_{iK})$ is an N x K matrix of regressors where x_1 is assumed to equal 1 in order to include a constant in the model
- $\boldsymbol{\beta} = (\beta_1 + \ldots + \beta_K)'$ is a K x 1 vector of parameters
- $\boldsymbol{\varepsilon} = (\varepsilon_i)$ is a 1 x N vector

That is,

$$\begin{pmatrix} y_1 \\ \vdots \\ y_N \end{pmatrix} = \begin{pmatrix} x_{11} & \cdots & x_{1K} \\ \vdots & & \vdots \\ x_{N1} & \cdots & x_{NK} \end{pmatrix} \begin{pmatrix} \beta_1 \\ \vdots \\ \beta_K \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_N \end{pmatrix}.$$

The OLS estimator of β is the vector of $\hat{\beta}$ that minimizes the sum of squared residuals leading to

$$\hat{\beta}_{OLS} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{y},$$

where $\mathbf{X}$ is the N x K data matrix of regressors with ith row $\boldsymbol{x}_i$ and $\mathbf{y}$ is an N x 1 data vector with ith element $\boldsymbol{y}_i$.

Specifying this estimation method for each of the instructional outputs (i.e. bachelor's degrees, master's degrees, and doctoral degrees) yields three separate equations. Each of these equations is first estimated separately via OLS. However, one of the limitations of employing OLS when multiple equations are involved is that this method is not able to account for correlated errors across equations also known as contemporaneous correlation. As such, the advantage of SUR is that it improves the efficiency of the parameters by accounting for this correlation (Cameron & Trivedi, 2009; Green, 2008; Wooldridge, 2002; Zellner, 1962). The implication of failing to account for contemporaneous correlation is that the equation-by-equation OLS estimation may yield biased results. Hence, SUR is employed to capture the information from the error term (i.e. residuals) across equations into the estimation of the β coefficients, which leads to Generalized Least Squares (GLS) and subsequently to FGLS estimation.

The SUR model begins with G linear regression equations for N individuals with i representing the individual and j the number of equations:

$$\boldsymbol{y}_{ij} = \mathbf{x}_{ij}\boldsymbol{\beta}_j + \boldsymbol{\varepsilon}_{ij}\ , \qquad j = 1, \dots\ ,$$

where $\mathbf{x}_{ij}$ is a 1 x K_j vector of regressors. If observations are stacked according to the jth equation the model becomes

$$\boldsymbol{y}_j = \mathbf{X}_j\boldsymbol{\beta}_j + \boldsymbol{\varepsilon}_j\ , \qquad j = 1, \dots\ ,$$

where $\boldsymbol{y}_j$ and $\boldsymbol{\varepsilon}_j$ are N x 1 vectors, $\mathbf{x}_j$ is a N x K_j matrix, and $\boldsymbol{\beta}_j$ is a K x 1 vector. Subsequently G equations are stacked on top of another to arrive at the SUR model represented by

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \ ,$$

or, in matrix form

$$\begin{pmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_G \end{pmatrix} = \begin{pmatrix} \mathbf{X}_1 & 0 & \dots & 0 \\ 0 & \mathbf{X}_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \mathbf{X}_G \end{pmatrix} \begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_G \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_G \end{pmatrix}.$$

The SUR model assumes independence in the error term across observations and contemporaneous correlation across equations (Cameron & Trivedi, 2009; Green, 2008; Wooldridge, 2002; Zellner, 1962). Thus,

$$E(\boldsymbol{\varepsilon}_i \boldsymbol{\varepsilon}'_j \mid \mathbf{X}_1, \mathbf{X}_2, \dots, \mathbf{X}_G) = \sigma_{ij}\, \mathbf{I}_N$$

or

$$E(\boldsymbol{\varepsilon}\boldsymbol{\varepsilon}' \mid \mathbf{X}_1, \mathbf{X}_2, \dots, \mathbf{X}_G) = \boldsymbol{\Omega} = \begin{pmatrix} \sigma_{11}\mathbf{I} & \sigma_{12}\mathbf{I} & \dots & \sigma_{1G}\mathbf{I} \\ \sigma_{21}\mathbf{I} & \sigma_{22}\mathbf{I} & \dots & \sigma_{2G}\mathbf{I} \\ & \vdots & & \\ \sigma_{G1}\mathbf{I} & \sigma_{G2}\mathbf{I} & \dots & \sigma_{GG}\mathbf{I} \end{pmatrix}.$$

And

$$\boldsymbol{\Omega} = \boldsymbol{\Sigma} \otimes \mathbf{I},$$

where

$$\boldsymbol{\Sigma} = \begin{pmatrix} \sigma_{11} & \sigma_{12} & \dots & \sigma_{1G} \\ \sigma_{21} & \sigma_{22} & \dots & \sigma_{2G} \\ & \vdots & & \\ \sigma_{G1} & \sigma_{G2} & \dots & \sigma_{GG} \end{pmatrix}$$

and

$$\mathbf{I} = \begin{pmatrix} 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1 \end{pmatrix},$$

where $\mathbf{I}$ is a Nx Nmatrix with ones on the principal diagonal and zeros off the principal diagonal. Then, for the entire system

$$\mathbf{\Omega} = E(\boldsymbol{\varepsilon\varepsilon}') = \mathbf{\Sigma} \otimes \mathbf{I}_N \ ,$$

where $\mathbf{\Sigma} = (\sigma_{jj'})$ is a G x G positive-definite matrix and ⊗ represents the Kronecker product of two matrices. Given that

$$\mathbf{\Omega} = \mathbf{\Sigma} \otimes \mathbf{I}_N \ .$$

Then, when using

$$\mathbf{\Omega}^{-1} = \mathbf{\Sigma}^{-1} \otimes \mathbf{I}_N \ ,$$

the GLS estimator is

$$\hat{\beta}_{GLS} = [\ \mathbf{X}'(\mathbf{\Sigma}^{-1} \otimes \mathbf{I}_N)\mathbf{X}\ ]^{-1}\ \ [\mathbf{X}'(\mathbf{\Sigma}^{-1} \otimes \mathbf{I}_N)\ \mathbf{y}]\ .$$

The formula for the GLS estimator presented above assumes that $\mathbf{\Sigma}$ is known, which is unlikely. Hence, the SUR model estimates β by employing the Feasible Generalized Least Squares (FGLS) method, which consists of a two step process. In the first step, each of the equations is estimated via OLS and the residuals from the G equations are used to estimate $\mathbf{\Sigma}$ with

$$\hat{\sigma}_{jj'} = \hat{\varepsilon}'_j\ \hat{\varepsilon}_{j'}\ /\ N\ .$$

In the second step, $\hat{\mathbf{\Sigma}}$ is substituted for $\mathbf{\Sigma}$ in the formula shown above for the GLS estimator, arriving as such to the FGLS estimator:

$$\hat{\beta}_{FGLS} = [\ \mathbf{X}'(\hat{\mathbf{\Sigma}}^{-1} \otimes \mathbf{I}_N)\mathbf{X}\ ]^{-1}\ \ [\mathbf{X}'(\hat{\mathbf{\Sigma}}^{-1} \otimes \mathbf{I}_N)\ \mathbf{y}]\ .$$

As previously indicated, the advantage of the SUR method via FGLS is to improve the efficiency of the parameters estimates when contemporaneous correlation is present across equations. If this is the case, single equation-by-equation estimation via OLS is not as efficient as SUR estimation via FGLS. However, there are two instances when FGLS is reduced to equation-by-equation OLS. The first instance is when correlation across equations is not statistically significant, so $\boldsymbol{\Sigma}$ is diagonal. The second instance is when each equation contains exactly the same set of regressors, even if $\boldsymbol{\Sigma}$ is nondiagonal. In either of these cases, the gain of estimating the equations simultaneously through the SUR method is either minimum or nonexistent (Cameron & Trivedi, 2009; Green, 2008; Wooldridge, 2002; Zellner, 1962).

Inasmuch as the second instance is not the case in this work when considering all three outputs, to test whether correlation across the equations in this study is statistically significant, the Lagrange multiplier (LM) statistic, as suggested by Breusch and Pagan (1980), is employed in chapter four after estimating the equations simultaneously through the SUR method. The LM statistic tests for independence across equations is

$$\lambda_{LM} = N \sum_{i=1}^{M} \sum_{j=1}^{i-1} r_{ij}^{2} .$$

Having determined the preferred estimator (i.e. OLS vis-à-vis FGLS), the equations in this study are then examined accordingly by employing robust standard errors to account for heteroskedasticity (Cameron & Trivedi, 2009; Green, 2008; Wooldridge, 2002, 2006), which is a common issue in econometric analysis.

Data

To examine the research questions and hypotheses in this study, data from the American Association of University Data Exchange (AAUDE) were analyzed. These data are collected on a yearly basis by the Office of Institutional Research at the University of Delaware as part of their national study of instructional costs and productivity (University of Delaware [UD] – Office of Institutional Research [IR], 2010). AAUDE/Delaware data have been employed by several researchers to conduct studies related to productivity on different academic years (Dundar & Lewis, 1995; d'Sylva, 1998; Nelson & Hevert, 1991; Santos, 2007; Ward, 1997).

For this study, access was granted to data on a random sample of eleven AAU public research universities for academic year 2005-2006. Data for these universities were collected at the departmental level, that is, by academic department. Academic departments were coded at the four-digit CIP level using the Classification of Instructional Programs (CIP) taxonomy developed by the U.S. Department of Education's National Center for Education Statistics (2002). The sample for this analysis encompassed academic departments for which complete data were available. This restriction yielded a sample of 235 academic departments for bachelor's degrees, 248 academic departments for master's degrees and 213 academic departments for doctoral degrees. The various academic departments were representative of different fields of study in AAU public research universities for the academic year mentioned above.

General Model

The general model is represented by

$$\mathrm{P}_i = \alpha_0 + \beta\, \mathbf{Z}_i + \gamma\, \mathbf{C}_i + \delta\, \mathbf{D}_i + \varepsilon_i\ , \qquad (1)$$

where degree production (P) in department i is a function of various departmental factors ($\mathbf{Z}$) in department i such as instructional type, size, and financial resources; ($\mathbf{C}_i$) represents several control variables; ($\mathbf{D}_i$) represents multiple dummy variables with a value of 1 for a selected field of study and a value of zero otherwise; (ε_i) is a random error term; and (β), (γ), and (δ) are parameters to be estimated. The outcome of interest, degree production (⍰), was examined for each of the instructional outputs measured by the number of degrees granted at each level (i.e. bachelor's degrees, master's degrees, and doctoral degrees) by the academic departments in the data set. Given the concept of production function employed in this study as part of its conceptual framework, and, the reasonable assumption that the instructional outputs examined in this study represent a combination of the various inputs respectively, the analysis in this research employs a double-log model. This model is characterized by transforming the dependent variable, as well as, the respective independent variables[5] into their logarithmic forms using the natural log. As such, a double-log model can be interpreted in terms of elasticity. This model is introduced in this analysis to capture decreasing or increasing marginal effects given the law of diminishing returns underlying a production function. For this particular analysis, some of the continuous independent variables are estimated by using percentages instead of logging them. Such variables can also be considered as part of the double-log model and interpreted in terms of elasticity.

Specific Equations

The specific equations include equation (2) for bachelor's degrees, equation (3) for master's degrees, and equation (4) for doctoral degrees. In all three equations, the percentage of tenured/tenure track faculty and the field of business management constitute reference categories respectively; as such, they are omitted from the equations. Also, the input figures measuring the departmental factors (instructional type, size, and financial resources) are representative of the whole department by CIP and not specific by degree program. A thorough explanation of each of the variables is provided in this section subsequent to the equations.

[5] Only continuous variables are logged, categorical or dummy variables remain unlogged with a value of 1 or 0 respectively.

Bachelor's degrees (logged) = $\alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \gamma_3 C_3 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \varepsilon$,

(2)

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the undergraduate level (logged)

C_2 = Class size at the undergraduate level (logged)

C_3 = Service field

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

Master's degrees (logged) = $\alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \varepsilon$,

(3)

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

$$\text{Doctoral degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \varepsilon , \quad (4)$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

Variables

The specific variables of interest are those mentioned in the research questions of this study, that is, instructional type, size, and financial resources.[6] The literature review in the previous chapter points to the importance of instructional FTE when analyzing production within higher education. As such, this study explores the impact of instructional FTE on the production of degrees by examining both academic departments' instructional type and instructional size. For the former, similar to Ehrenberg and Zhang (2005), instructional type is examined by using percentages. For the latter, the department's total instructional FTE is employed. In this study, students' credit hours are omitted from the models for two reasons: 1) it is emphasized throughout the literature review that student credit hours constitute an output rather than an input and 2) student credit hours, in these data, are highly correlated with instructional FTE creating as such potential issues of multicollinearity.

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[6] Given the data set for this study, the variables measuring instructional type, size, and financial resources are representative of the whole department by CIP and not specific by degree program.

The percentage of credit-bearing teaching assistants and non-credit bearing teaching assistants are also included within the equations for master's degrees and doctoral degrees mainly for modeling reasons. That is, the instructional type variables within the equations are considered as percentages where the sum of all of these categories adds to 100%. As such, when performing the regression analysis, these variables take a similar form as it is the case when modeling categorical or dummy variables where one of the categories within the group needs to be omitted from the regression in order to avoid what is known as the dummy variable trap. The omitted category becomes the reference category to which the other variables within that particular group are compared to in the output. Thus, if the variables measuring the percentage of credit-bearing teaching assistants and non-credit bearing teaching assistants are omitted from the equations for master's and doctoral degrees, these would become the reference category to which the other variables would have to be compared to. Considering that this would not make a meaningful comparison, this study includes the respective variables measuring the percentage of instructional type and omits the percentage for tenured/tenure track faculty in all of the equations in order to have a meaningful comparison when examining the results of the analysis.

In addition to instructional FTE, the literature review in this study (in particular the segment that examined degree production studies) also points to the importance of financial resources for examining the production of degrees. Hence, instructional expenditures and research expenditures are included within each of the models to account for this factor. As such, these constitute additional variables of interest within the analysis. The remaining variables in the respective equations serve as controls to account for differences across the various academic departments.

Next, each of the variables employed in the equations is defined and described. Some of the definitions in this segment are taken from the Delaware study of instructional cost and productivity (commonly known as simply Delaware Study) provided by Middaugh (2001) and by the Office of Institutional Research at the University of Delaware (UD-IR, 2010). Subsequently, additional variables are discussed and introduced in order to control for quality, which is emphasized in the research questions of this study and addressed in the cost studies as one of the main issues and most pervasive limitations when modeling production within higher education.

Bachelor's degrees – Bachelor's degrees awarded per CIP (logged)

Bachelor's degrees – represents the number of bachelor's degrees awarded per CIP at the four-digit level and it constitutes the dependent variable of this study at the undergraduate level. This variable is estimated in its logarithmic form.

Master's degrees – Master's degrees awarded per CIP (logged)

Master's degrees – represents the number of master's degrees awarded per CIP at the four-digit level and it constitutes one of the dependent variables in this study at the graduate level. This variable is estimated in its logarithmic form.

Doctoral degrees – Doctoral degrees awarded per CIP (logged)

Doctoral degrees – represents the number of doctoral degrees awarded per CIP at the four-digit level and it constitutes the second dependent variable in this study at the graduate level. This variable is estimated in its logarithmic form.

% Tenured/tenure track – Percentage of tenured/tenure track faculty (reference category)

% Tenured/tenure track – constitutes the percentage of tenured/tenure track faculty out of total instructional FTE per CIP. As indicated by the Delaware Study tenured/tenure track is defined as regular faculty who are hired on a recurring contractual relationship for teaching, who may also do research and/or service, and are those faculty members who either have already obtained tenure, or for whom tenure is expected (Middaugh, 2001; UD-IR, 2010). Tenured/tenure track faculty include full, associate, and assistant professors. This variable is omitted in all of the equations in order to make it the reference category so that meaningful results may be reported in the analysis.

% Non-tenure track – Percentage of non-tenure track faculty

% Non-tenure track – represents the percentage of non-tenure track faculty out of total instructional FTE per CIP. Non-tenure track faculty members are also hired on a recurring contractual relationship for teaching and may also do research and/or service. However, these individuals are ineligible for academic tenure. Non-tenure track faculty include instructors, lectures, and visiting faculty among others (Middaugh, 2001; UD-IR, 2010).

% Part-time – Percentage of part-time faculty

% Part-time – represents the percentage of part-time faculty out of total instructional FTE per CIP. Supplemental faculty members are those hired to teach who are usually paid out of temporary funds. The key aspect of this type of faculty is that the source of funding is temporary. Hence, there is no expectation of continuing appointment although the same faculty member might be given a temporary appointment in subsequent academic terms. This category includes adjuncts, administrators, professional personnel at the institution whose primary job responsibility is non-faculty but who teach (Middaugh, 2001; UD-IR, 2010).

% TA credit – Percentage of credit bearing teaching assistants

% TA credit – constitutes the percentage of teaching assistants with credit bearing out of total instructional FTE per CIP. Teaching assistants are students who receive a stipend for teaching. Teaching assistants with credit bearing courses are those who are instructors of record. Graduate research assistants are not included in the data set. If a graduate research assistant's FTE performs both teaching and research, only the portion that reflects their FTE for teaching is reported (Middaugh, 2001; UD-IR, 2010).

% TA non-credit – Percentage of non-credit bearing teaching assistants

% TA non-credit – represents the percentage of teaching assistants with non-credit bearing activity out of total instructional FTE per CIP. Teaching assistants with non-credit bearing activity are also students who receive a stipend for teaching. However, they "function as discussion section leaders, laboratory section leaders, and other types of organized class sections in which instruction takes place but which may not carry credit and for which there is no formal instructor of record" (UD-IR, 2010).

Tot. instruct. FTE (log) – Total instructional FTE (logged)

Tot. instruct. FTE (log) – comprehends FTE for all of the instructional types listed above (i.e. tenured/tenure track faculty, non-tenure track faculty, part-time faculty, credit bearing teaching assistants, and non-credit bearing teaching assistants) per CIP. This variable is used to measure academic departments' size. This variable is introduced into the equations by using its logarithmic form.

Direct instruct. exp. (log) – Direct instructional expenditures (logged)

Direct instruct. exp. (log) – represents average instructional expenditures per credit hour taught per CIP. This variable was obtained via the Delaware Study methodology

(Middaugh, 2001; UD-IR, 2010). That is, by dividing academic departments' (by CIP) total instructional expenditures for the fiscal year by their total number of undergraduate and graduate student credit hours for the academic year. As with the previous variable (total instructional FTE). Middaugh (2001) and UD-IR (2010), explain that total instructional expenditures for the fiscal year include salaries and benefits of faculty and staff such as clerical workers (e.g. department secretary), professionals (e.g. lab technicians), teaching assistants (tuition waivers excluded), and any other personnel who support the teaching function and whose salaries and wages are paid from the department's instructional budget. In addition, Middaugh (2001) and UD-IR (2010) indicate that total instructional expenditures also include other than personnel costs such as travel, supplies and expense (e.g. printing and search expenses), and non-capital equipment purchases (lab supplies, office equipment and software) among others that are most commonly part of an academic unit or academic program's cost of doing business. Finally, Middaugh (2001) and UD-IR (2010) point out that expenses such as central computing costs, centrally allocated computing labs, graduate student tuition remission and fee waivers, and the like are exclude from this category. This variable is introduced into the equations by using its logarithmic form.

Research exp. (log) – Research expenditures per tenured/tenure track faculty (logged)

Research exp. (log) – denotes separately budgeted research expenditures per FTE tenured/tenure track faculty by CIP. Tenured/tenure track faculty were selected for this variable in that this particular instructional type is expected to generate contracts and grants. This variable was also obtained via Delaware Study methodology (Middaugh, 2001; UD-IR, 2010). That is, by dividing academic departments' (by CIP) yearly research expenditures for the fiscal year by tenured/tenure track total faculty FTE for the academic year. Research expenditures include “all funds expended for activities specifically organized to produce research outcomes and commissioned by an agency either external to the institution or separately budgeted by an organizational unit within the institution” (UD-IR, 2010). This variable is introduced into the equations by using its logarithmic form.

Org. sec. TTT_UND (log) – Organized class sections taught per tenured/tenure track faculty at the undergraduate level (logged)

Org. class TTT_UND (log) – comprises the average number of organized class courses taught per instructional FTE for tenured/tenure track faculty at the undergraduate level by CIP. This variable was obtained via Delaware Study methodology (Middaugh, 2001; UD-IR, 2010) by dividing the total number of organized class courses taught by tenured/tenure track faculty at the undergraduate level by tenured/tenure track instructional FTE. “An organized class course is provided principally by means of regularly scheduled classes meeting in classrooms or similar facilities at stated times” (Middaugh, 2001 p.169). This variable is introduced in the model for the production of bachelor’s degrees to account for tenured/tenure track faculty workload across academic departments at the undergraduate level and is estimated in its logarithmic form.

Org. sec. TTT_GRAD (log) – Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

Org. sec. TTT_ GRAD (log) – encompasses the average number of organized class courses taught per instructional FTE for tenured/tenure track faculty at the graduate level by CIP. This variable was obtained via Delaware Study methodology (Middaugh, 2001;

UD-IR, 2010) by dividing the total number of organized class courses taught by tenured/tenure track faculty at the graduate level by tenured/tenure track instructional FTE. This variable is introduced in the models for the production of masters' and doctoral degrees respectively to account for tenured/tenure track faculty workload across academic departments at the graduate level and is estimated in its logarithmic form.

Class size UND (log) – Class size at the undergraduate level (logged)

Class size UND (log) – comprises the average number of students' school credit hours per organized class course at the undergraduate level by CIP. This variable was obtained employing Nelson and Hevert's (1992) method. That is, dividing the total number of students' school credit hours at the undergraduate level by the total number of organized class courses at that level per CIP. This variable is introduced in the model for the production of bachelor's degrees to control for average class size at the undergraduate level, which the cost studies have argued as a necessary control when modeling production in higher education, and is estimated in its logarithmic form.

Class size GRAD (log) – Class size at the graduate level (logged)

Class size GRAD (log) – comprises the average number of students' school credit hours per organized class course at the graduate level by CIP. This variable was obtained employing Nelson and Hevert's (1992) method. That is, dividing the total number of students' school credit hours at the graduate level by the total number of organized class courses at that level per CIP. This variable is introduced in the models for the production of masters' and doctoral degrees respectively to control for average class size at the graduate level, which the cost studies have argued as a necessary control when modeling production in higher education, and is estimated in its logarithmic form.

Service field – Service field

Service field – is a dummy variable coded 1 if the academic department at the four-digit CIP level represents a service field, otherwise it is coded 0. A service field is defined in this study as an academic department at the four-digit CIP level that offers classes that are required within the general education curriculum for attainment of a bachelor's degree. This variable is introduced in the model for the production of bachelor's degrees to account for differences in demand across departments due to the general education requirements for graduation. A list of the academic departments that were coded as service fields is provided in Appendix A.

STEM – STEM

STEM – is a dummy variable coded 1 if the academic department at the four-digit CIP level is considered a STEM field, otherwise it is coded 0. A STEM field is an academic area related to science, technology, engineering, or mathematics. The *Survey of Research and Development Expenditures at Universities and Colleges* provided by NSF (2005) was used as a guide for the coding scheme. This variable is introduced in all of the equations respectively to account for differences in degree production across fields of study. A list of the academic departments that were coded as STEM fields is provided in Appendix B.

Social Sciences – Social sciences

Social Sciences – is a dummy variable coded 1 if the academic department at the four-digit CIP level falls within the social sciences, otherwise it is coded 0. The *Survey of Research and Development Expenditures at Universities and Colleges* provided by NSF (2005) was used as a guide for the coding scheme. This variable is introduced in all of the equations respectively to account for differences in degree production across fields of study. A list of the academic departments that were coded as social sciences is provided in Appendix C.

Humanities – Humanities

Humanities – is a dummy variable coded 1 if the academic department at the four-digit CIP level falls within the field of humanities, otherwise it is coded 0. The *Survey of Research and Development Expenditures at Universities and Colleges* provided by NSF (2005) was used as a guide for the coding scheme. This variable is introduced in all of the equations respectively to account for differences in degree production across fields of study. A list of the academic departments that were coded as humanities is provided in Appendix D.

Business Management – Business management (reference category)

Business Management – is a dummy variable coded 1 if the academic department at the four-digit CIP level represents the area of business management, otherwise it is coded 0. The *Survey of Research and Development Expenditures at Universities and Colleges* provided by NSF (2005) was used as a guide for the coding scheme. This variable is omitted in all of the equations in order to make it the reference category so that meaningful results may be reported in the analysis. A list of the academic departments that were coded as business management fields is provided in Appendix E.

Quality

The research questions in this study state accounting for quality when estimating the various equations. However, as indicated in the cost studies, controlling for quality remains one of the most pervasive limitations when modeling production in higher education. This is usually the case due to the difficulty of finding appropriate measures for this variable. As such, there are no standard or accepted measures for quality in higher education (Dundar & Lewis, 1995). For this reason, as previously indicated, many have ignored quality by not including this control in their models while others have attempted to control for it via some sort of proxy or measure related to it. Within higher education, class size (James, 1978, 1990; James and Neuberger, 1981; Nelson and Hevert, 1992, Tierney, 1980), instructional expenditures (Schmitz, 1993; Ward, 1997), grants and contracts (Volk et al., 2001), and average faculty salaries (Rhodes & Southwick, 1993; Tierney, 1980) have been mentioned as possible controls for quality. The former holds the assumption that smaller class size represents higher quality while the opposite is the case for the other three measures. That is, the higher the amount of instructional expenditures, grants and contracts, and average faculty salary the higher the level of quality.

Class size was employed by Nelson and Hevert (1992) in their model while Ward (1997) used instructional expenditures as a proxy for quality. Volk et al. (2001), in their study used external dollars in grants to account for quality in addition to their own quality score measure. Additionally, Tierney (1980) argued that average faculty salaries, as well as, greater capital resources (a measure related to instructional expenditures) constitute other measures for quality, and, Rhodes and Southwick (1993) used faculty average salary as a measure for quality in their analysis.

This study, following on the work of Nelson and Hevert (1992) includes a control for class size at the undergraduate and graduate levels respectively, capturing as such differences in educational technology across departments, and, controlling for quality differentials based on the argument of James (1978, 1990); James and Neuberger (1981); and Tierney (1980), who assume higher quality for smaller class size. Moreover, differences in quality across academic units are further taken into account through the variable direct instructional expenditures per credit hour taught per CIP, which is included in the equations mainly to examine the effect of this financial variable on the production of degrees.

In addition to accounting for quality differentials across units through class size and instructional expenditures, this study specifically accounts for quality by employing four different alternatives. In the next chapter, the respective equations are modeled with each of these alternatives. The results are reported and a sensitivity analysis is presented to show the effects of each alternative.

The first alternative in this study, similar to Volk et al. (2001) uses a measure related to contracts and grants. As such, the variable research expenditures per tenured/tenure track faculty is employed as a control for quality. This variable however has already been introduced in all of the equations as part of the financial variables. Hence, research expenditures per tenured/tenure track faculty, in addition to examining its impact on degree production, also acts as a control for quality differentials among academic departments in the production of degrees.

The second alternative, following Tierney's (1980) argument and Rhodes and Southwick (1993) employs average faculty salary as a proxy for quality. However, there is a caveat and a limitation with this variable in this data set. One cannot obtain a true measure of average faculty salary because the data set does not disaggregate salaries by instructional type. Instead, the data set provides a variable for salaries for all faculty and staff, which includes clerical workers (e.g. department secretary), professionals (e.g. lab technicians), teaching assistants, and any other personnel who support the teaching function in the department. As such, this proxy does not represent a true measure of average faculty salary, but it is rather an approximation, which is used to account for quality given that the data set lacks a quality variable per se.

Nonetheless, when examining the average faculty salary for the group of institutions employed in this study from the Integrated Postsecondary Education Data System (IPEDS) for year 2005, it turns out that for all faculty members on a two-semester contract the average salary is $75,620. This value is almost the same as the value of the means obtained from the proxy for quality constructed in this study, which is $75,759 for the bachelor's degrees data and $75,454 for master's degrees and doctoral degrees data. Hence, this proxy for quality appears to be a good approximation for average faculty salary for the institutions in this study. In addition, this proxy variable is able to account for differentials across departments, and as such, to account for quality in that it is calculated in the same way for all of the departments in the data set. Further explanation concerning the construction of this variable is provided below.

The third alternative employed in this study is the omission of the proxy for quality and the inclusion of a measure for institutional quality instead. This alternative is employed following the method of Tierney (1980) who assigned a quality score to each academic department based on the institutional score. For this alternative, this study uses the institutional score provided by the *U.S. News and World Report* when comparing universities across the United States. Given that this is an institutional score, it is assumed that various institutional characteristics are, in a way, controlled for with this variable, especially when considering the different measures and weights that are employed for the calculation of this score. These measures and their respective weights are as follows: peer assessment score (15%), high school counselor score (7.5%), graduation and retention rank (20%), faculty resources rank (20%), selectivity rank (15%), financial resources rank (10%), alumni giving rank (5%), and graduation rate performance (7.5%).

The fourth alternative used in this study is the inclusion of both the proxy for quality and the *U.S. News* institutional quality score. These two variables are included as a fourth alternative to examine their joint effect in estimating the various equations. The proxy variable for quality and the *U.S. News* institutional quality score variable are presented next in order to define them and describe the way they were obtained. Having explained the different variables and the issue related to quality, the subsequent segment presents the additional equations estimated in chapter four.

Proxy for qual. (log) – Proxy for quality (logged)

Proxy for qual. (log) – is an approximation of average faculty salary and represents the proxy for quality. This variable was obtained by diving salaries for faculty and staff during the fiscal year by total faculty FTE. As previously indicated, salaries include all wages paid to support the instructional function in a given department or program during the fiscal year. These entail the salaries of faculty, clerical (e.g., department secretary), professionals (e.g., lab technicians), graduate student stipends (but not tuition waivers), and any other personnel who support the teaching function and whose salaries and wages are paid from the department's instructional budget. Total faculty FTE includes both instructional FTE and research FTE for all types of faculty (i.e. tenured/tenure track faculty, non-tenure track faculty, adjunct faculty, and graduate assistants). This variable is introduced into the equations by using its logarithmic form.

Inst. qual. score (log) – Institutional quality score (logged)

Inst. qual. score (log) – represents the institutional score provided by *U.S. News and World Report* when comparing universities across the United States. The highest score equals 100 points and it is based on the measures and weights indicated above. For this study, the latest institutional score as reported in the 2011 *U.S. News and World Report* was employed in order to account for the most recent adjustment of weights and measures used by *U.S. News and World Report* to arrive at such score. This variable is introduced into the equations by using its logarithmic form.

Additional Equations Estimated in Chapter Four

For the production of bachelor's degrees, equation (2) as previously presented and equations (5), (6), and (7) included below are estimated. For the production of master's degrees, equation (3) as previously presented and equations (8), (9), and (10) included below are estimated. For the production of doctoral degrees, equation (4) as previously presented and equations (11), (12), and (13) included below are estimated. As already indicated, the input figures measuring the departmental factors (instructional type, size, and financial resources) are representative of the whole department by CIP and not specific by degree program.

The difference among the equations for each degree type is the way each model attempts to account for quality. That is, for each degree type (i.e. bachelor's degrees, master's degrees, and doctoral degrees) four different equations are estimated: the first equation [equations (2), (3), & (4) respectively] employs research expenditures per tenured/tenure track faculty as a control for quality, the second equation [equations (5), (8), & (11) respectively] adds a proxy for quality, the third equation [equations (6), (9), & (12) respectively] uses an institutional quality score instead of the proxy for quality, and the fourth equation [equations (7), (10), & (13) respectively] includes both the proxy for quality and the institutional quality score to examine their joint effect on the production of degrees. For a more concise explanation on differences and similarities among these equations by degree type see the summary table in Appendix F.

The results of the four equations for each degree type are presented and compared. Special attention is given to the stability of the coefficients across the equations and the impact of controlling for quality via the different alternatives. The four equations for each of the outputs are estimated with the preferred estimator (i.e. OLS vis-à-vis FGLS) after performing the Breusch-Pagan test. Finally, it is important to point out that this study takes into account quality, unit of analysis, and class size, which are issues that the cost studies have indicated need to be considered when modeling production within higher education.

$$\text{Bachelor's degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \gamma_3 C_3 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_4 C_4 + \varepsilon \,, \quad (5)$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the undergraduate level (logged)

C_2 = Class size at the undergraduate level (logged)

C_3 = Service field

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_4 = Proxy for quality (logged)

$$\text{Bachelor's degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \gamma_3 C_3 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_4 C_4 + \varepsilon , \quad (6)$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the undergraduate level (logged)

C_2 = Class size at the undergraduate level (logged)

C_3 = Service field

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_4 = Institutional quality score (logged)

Bachelor's degrees (logged) = $\alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 +$

$\gamma_2 C_2 + \gamma_3 C_3 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_4 C_4 + \gamma_5 C_5 + \varepsilon$,

(7)

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the undergraduate level (logged)

C_2 = Class size at the undergraduate level (logged)

C_3 = Service field

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_4 = Proxy for quality (logged)

C_5 = Institutional quality score (logged)

Master's degrees (logged) = $\alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_3 C_3 + \varepsilon$,

(8)

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_3 = Proxy for quality (logged)

Master's degrees (logged) = $\alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_3 C_3 + \varepsilon$,

(9)

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_3 = Institutional quality score (logged)

$$\text{Master's degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_3 C_3 + \gamma_4 C_4 + \varepsilon, \quad (10)$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_3 = Proxy for quality (logged)

C_4 = Institutional quality score (logged)

$$\text{Doctoral degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_3 C_3 + \varepsilon, \quad (11)$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_3 = Proxy for quality (logged)

$$\text{Doctoral degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_3 C_3 + \varepsilon, \tag{12}$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_3 = Institutional quality score (logged)

$$\text{Doctoral degrees (logged)} = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \gamma_1 C_1 + \gamma_2 C_2 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \gamma_3 C_3 + \gamma_4 C_4 + \varepsilon, \quad (13)$$

where

Z_1 = Percentage of non-tenure track faculty

Z_2 = Percentage of part-time faculty

Z_3 = Percentage of credit bearing teaching assistants

Z_4 = Percentage of non-credit bearing teaching assistants

Z_5 = Total instructional FTE (logged)

Z_6 = Direct instructional expenditures (logged)

Z_7 = Research expenditures per tenured/tenure track faculty (logged)

C_1 = Organized class sections taught per tenured/tenure track faculty at the graduate level (logged)

C_2 = Class size at the graduate level (logged)

D_1 = STEM

D_2 = Social sciences

D_3 = Humanities

C_3 = Proxy for quality (logged)

C_4 = Institutional quality score (logged)

Limitations

As with any study, there are several limitations to the data that need to be considered. First, the sample for this study is limited to AAU public research universities; data on non-AAU public research universities were not available for this analysis. Second, because the data were provided on a small number of institutions the sample is not large. However, it is a random sample that focuses on academic departments (by CIP) rather than on institutions and as such the sample is representative of academic units within different fields of study. Third, the input figures measuring the departmental factors (instructional type, size, and financial resources) are representative of the whole department by CIP and not specific by degree program. Fourth, the data for this study is cross-sectional rather than panel. The latter, is usually preferred in that panel data are able to account for the omitted variable bias issue. Nonetheless, this study constructed the various equations presented taking into consideration this issue by employing the appropriate regressors according to theory and availability of variables within the data provided.

Fifth, this study approaches the analysis of degree production from a supply standpoint. As such, supply shapes the model where it is assumed that the regressors are exogenous. That is, the input variables employed in the different equations have a causal effect on the output produced, which in this case is degree production. For example, looking at total instructional FTE, the model in this study indicates that the number of instructional FTE at a given department causes the number of degrees in that department to either increase or decrease. However, from a demand standpoint, someone can argue the opposite to be the case. That is, the number of degrees produced at a department has a causal effect on the number of instructional FTE at that department. This potential two-way causation, also known as endogeneity, can be tested and accounted for by replacing the potential endogenous regressor on question with an appropriate proxy variable or variables, also known as instrumental variable (IV). For a variable to be considered an appropriate instrument, it needs to be highly correlated with the potential endogenous regressor and uncorrelated with the error term in the equation.[7] However, no such variables are available in the data set provided.

Thus, the possibility of a two-way causation or supply and demand interacting with each other is present in these data and as such is noted as a limitation. The working assumption of the statistical model in this study concerning instructional FTE, where it is assumed that the faculty workforce produces the degrees, ignores the possibility that the demand for the degrees is driving the faculty workforce. Given the lack of additional variables in the data set, it is impossible to either test for this potential two-way causation and or account for endogeneity via instrumental variables as indicated above.

Sixth, this study examined degree production by analyzing the number of degrees awarded per CIP by level (i.e. bachelor's degrees, master's degrees, and doctoral degrees) for a single academic year. Similar to de Groot et al. (1991), the number of degrees awarded was assigned to the year that input data was collected. One of the issues with this methodology is that degrees are awarded over a period of time; that is, two to four or six years from first enrollment, depending on the type of degree. However, building on the argument of de Groot et al. (1991), Dundar and Lewis (1995), and Hopkins and Massy (1981), it was assumed that the input variables had a similar pattern over the time it took to produce these degrees. De Groot et al.

[7] Determining the appropriate IV can be considered a conceptual exercise, which is somewhat relative in that the appropriateness of the instrument is going to depend on the way the person choosing the IV sees it.

(1991) employed this argument in their cross-sectional analysis of cost for a single year where earned undergraduate and graduate degrees respectively were used as output measures as an alternative to enrollment. Dundar and Lewis (1995) used a similar reasoning to introduce a measure of research in their cost model where publication data collected in 1981 were employed in their cross-sectional analysis of academic year 1985 – 1986. Hopkins and Massy (1981) used the foregoing as a fundamental assumption of their model, which assumed a static equilibrium in its flow system. That is, it was assumed that the flow rates of students, the behavioral and technological parameters, and the institutional constraints were similar in one year as in the next given the maturity of the academic programs being analyzed. The latter, represent the key for the robustness of the aforementioned assumption. Dundar and Lewis (1995) and Hopkins and Massy (1981) agree that if the departments being examined are somewhat mature, that is they have reached a reasonable size, the data for the most part are going to remain stable over certain periods of time. This study, considered the academic units in the analysis to be somewhat mature in that they belong to established universities that have been in operation for a considerable period of time.

Finally, disaggregation of total instructional expenditures (i.e. salaries, benefits, and non-personal costs) by level (i.e. undergraduate and graduate) and by instructional type (i.e. tenured/tenure track faculty, non-tenure track faculty, adjunct faculty, and graduate assistants) was not available in the data set provided. And, although the data set disaggregated funds between separately budgeted research expenditures and total instructional expenditures, no disaggregation was available within instructional expenditures for funds assigned towards departmental research. Nonetheless, this is a common issue shared by the cost studies and emphasized by James (1978). For this reason, the Delaware Study methodology (Middaugh, 2001; UD-IR, 2010) was employed for the construction of the instructional expenditure variable, which poses a widely used and, as such, accepted statistic that has been employed in cost studies (Toutkoushian, 1999).

CHAPTER 4

FINDINGS

Prior to reporting the findings of the analysis, the variables employed in the different equations are examined via descriptive statistics. Then, two correlation tables are analyzed with emphasis on the zero-order correlations for each of the dependent variables in this analysis. Having gained further understanding concerning the variables employed in this study, the results of the Breusch-Pagan test are discussed and the preferred estimator for the analysis is determined (i.e. OLS vis-à-vis FGLS). Subsequently, the research questions and hypotheses of this study are examined by analyzing the results of estimating equations (2) through (13). Furthermore, the standardized coefficients of equations (2) through (13) are evaluated to further explore research question two. In addition, the dummy variables representing the different fields of study are examined to supplement the analysis of research question three and hypotheses four and five.

Descriptive Statistics

Table 1, Table 2, and Table 3 provide the descriptive statistics for this study. Table 1 reports on the variables employed to model bachelor’s degrees while Table 2 and Table 3 report on the variables employed to model master’s degrees and doctoral degrees respectively. A close inspection of these tables indicates that the mean of the majority of the variables remains about the same in all three tables. However, three different tables are provided in order to report accurate information concerning the variables for each of the models. For the logged variables, both its based form and logarithmic form are provided to examine the descriptive statistics of these variables.

Table 1, Table 2, and Table 3 respectively show that academic departments (by CIP at the 4 digit-level) in each of the respective samples of this study, at the mean, produced 96 bachelor's degrees, 25 master's degrees, and 8 doctoral degrees for academic year 2005-2006. Total instructional FTE averaged 32, out of which 59% were tenured/tenure track faculty followed by part-time faculty (14%) and teaching assistants with credit bearing (11%). The lowest percentages of instructional FTE per academic department, on average, were for non-tenure track faculty (7%) and teaching assistants with non-credit bearing activity (7%). Direct instructional expenditures per credit hour taught averaged $296 for bachelor's degrees, $318 for master's degrees, and $324 for doctoral degrees while research expenditures per tenured/tenure track faculty averaged $147,630 for bachelor's degrees, $204,228 for master's degrees, and $223, 679 for doctoral degrees. Tenured/tenure track taught an average of 1.6 organized class sections at the undergraduate level and an average of 1.0 organized class sections at the graduate level. Class size at the undergraduate level averaged 146 school credit hours and 30 school credit hours at the graduate level. Service field for bachelor's degrees constituted 56% of the sample. As far as the dummy variables representing the fields of study, out of the total sample respectively, for bachelor's degrees STEM represented 42%, social sciences 27%, humanities 25%, and business management 5%. For master's degrees, STEM represented 44%, social sciences 29%, humanities 22%, and business management 4%. For doctoral degrees, STEM represented 49%, social sciences 29%, humanities 20%, and business management 2%. Finally, the proxy for quality, measured by average faculty salary, averaged $75,000 while the institutional quality score averaged 50 points per CIP.

Table 1

Bachelor's Degrees - Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Bachelor's degrees	235	95.766	114.459	1.000	830.000
Bachelor's degrees (log)	235	3.941	1.202	0.000	6.721
% Tenured/tenure track	235	59.026	17.332	3.470	100.000
% Non-tenure track	235	7.716	11.379	0.000	60.801
% Part-time	235	14.083	14.938	0.000	87.063
% TA credit	235	11.662	11.864	0.000	50.756
% TA non-credit	235	7.515	11.214	0.000	47.205
Tot. instructional FTE	235	32.129	26.183	3.170	145.160
Tot. instruct. FTE (log)	235	3.186	0.768	1.154	4.978
Direct instruct. exp.	235	296.421	179.291	79.643	1102.179
Direct instruct. exp. (log)	235	5.545	0.531	4.378	7.005
Research exp.	235	147630.700	301749.100	1.000	3049843.000
Research exp. (log)	235	8.791	4.445	0.000	14.931
Org. class TTT_UND	235	1.633	2.143	0.084	18.182
Org. class TTT_UND (log)	235	0.165	0.716	-2.476	2.900
Class size UND	235	146.449	95.359	5.283	603.476
Class size UND (log)	235	4.771	0.707	1.664	6.403
Service field	235	0.557	0.498	0.000	1.000
STEM	235	0.421	0.495	0.000	1.000
Social Sciences	235	0.272	0.446	0.000	1.000
Humanities	235	0.251	0.435	0.000	1.000
Business Management	235	0.055	0.229	0.000	1.000
Proxy for qual.	235	75674.610	26425.500	24982.880	207770.600
Proxy for qual. (log)	235	11.176	0.347	10.126	12.244
Inst. qual. score	235	50.221	11.661	38.000	70.000
Inst. qual. score (log)	235	3.890	0.227	3.638	4.248

(log) variables use the natural logarithm

Table 2

Master's Degrees - Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Master's degrees	248	24.641	43.013	1.000	524.000
Master's degrees (log)	248	2.568	1.099	0.000	6.261
% Tenured/tenure track	248	59.054	17.493	7.554	100.000
% Non-tenure track	248	7.545	11.227	0.000	60.801
% Part-time	248	14.048	14.631	0.000	69.942
% TA credit	248	11.404	11.789	0.000	50.756
% TA non-credit	248	7.949	12.504	0.000	79.630
Tot. instructional FTE	248	31.319	25.918	1.620	145.160
Tot. instruct. FTE (log)	248	3.147	0.792	0.482	4.978
Direct instruct. exp.	248	318.885	192.086	79.643	1102.179
Direct instruct. exp. (log)	248	5.610	0.552	4.378	7.005
Research exp.	248	204228.100	974076.600	1.000	14800000.000
Research exp. (log)	248	8.915	4.374	0.000	16.508
Org. sec. TTT_ GRAD	248	1.076	1.277	0.013	9.818
Org. sec. TTT_ GRAD (log)	248	-0.303	0.837	-4.325	2.284
Class size GRAD	248	30.324	17.515	2.927	114.417
Class size GRAD (log)	248	3.244	0.611	1.074	4.740
STEM	248	0.440	0.497	0.000	1.000
Social Sciences	248	0.294	0.457	0.000	1.000
Humanities	248	0.222	0.416	0.000	1.000
Business Management	248	0.044	0.206	0.000	1.000
Proxy for qual.	248	75155.670	25940.810	22921.890	207770.600
Proxy for qual. (log)	248	11.169	0.347	10.040	12.244
Inst. qual. score	248	50.294	11.771	38.000	70.000
Inst. qual. score (log)	248	3.891	0.229	3.638	4.248

(log) variables use the natural logarithm

Table 3

Doctoral Degrees - Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Doctoral degrees	213	7.690	5.973	1.000	35.000
Doctoral degrees (log)	213	1.751	0.799	0.000	3.555
% Tenured/tenure track	213	59.282	17.418	7.554	100.000
% Non-tenure track	213	6.931	10.497	0.000	59.628
% Part-time	213	14.067	14.539	0.000	68.607
% TA credit	213	11.805	11.948	0.000	50.756
% TA non-credit	213	7.917	11.936	0.000	58.363
Tot. instructional FTE	213	33.709	26.889	2.270	145.160
Tot. instruct. FTE (log)	213	3.232	0.785	0.820	4.978
Direct instruct. exp.	213	324.262	192.219	79.643	1102.179
Direct instruct. exp. (log)	213	5.629	0.550	4.378	7.005
Research exp.	213	223679.200	1041507.000	1.000	14800000.000
Research exp. (log)	213	9.095	4.377	0.000	16.508
Org. sec. TTT_ GRAD	213	1.066	1.233	0.013	8.108
Org. sec. TTT_ GRAD (log)	213	-0.313	0.832	-4.325	2.093
Class size GRAD	213	28.624	15.744	2.927	113.216
Class size GRAD (log)	213	3.201	0.588	1.074	4.729
STEM	213	0.488	0.501	0.000	1.000
Social Sciences	213	0.286	0.453	0.000	1.000
Humanities	213	0.202	0.402	0.000	1.000
Proxy for qual.	213	0.023	0.152	0.000	1.000
Proxy for qual. (log)	213	74637.450	25700.300	12868.500	207770.600
Inst. qual. score	213	11.160	0.363	9.463	12.244
Inst. qual. score (log)	213	51.146	12.015	38.000	70.000
Inst. qual. score (log)	213	3.907	0.233	3.638	4.248

(log) variables use the natural logarithm

Correlation Table

The traditional Pearson's r correlation was employed in this study. A separate correlation table is provided for each of the degree types to show a clear presentation of both the correlations between the regressors and the respective dependent variables and the correlations among the regressors according to each of the models. Table 4 shows that for bachelor's degrees, total instructional FTE has the strongest zero-order correlation with the dependent variable (.52) followed by the field of social sciences (.29), STEM (-.27), class size (.26), and the proxy for quality (.20). Table 5 indicates that for master's degrees, class size has the strongest zero-order correlation with the dependent variable (.46) followed by the proxy for quality (.34), total instructional FTE (.33), direct instructional expenditures (.27), and the field of business management (.23). Table 6 shows that total instructional FTE has the strongest zero-order correlation with the dependent variable doctoral degrees (.49) followed by the proxy for quality (.26), class size (.18), direct instructional expenditures (.17), and humanities (-.17). As far as correlations among regressors, there are no concerns for multicollinearity in that the highest correlations among continuous variables do not exceed r = .5 within Tables 4, 5, and 6.

Table 4

Bachelor's Degrees - Correlation Table

	Bachelor's degrees (log)	% Tenured/ tenure track	% Non-tenure track	% Part-time	% TA credit	% TA non-credit
Bachelor's degrees (log)	1.000					
% Tenured/tenure track	-0.143	1.000				
% Non-tenure track	0.103	-0.451	1.000			
% Part-time	-0.014	-0.318	-0.306	1.000		

% TA credit	0.027	-0.366	-0.168	-0.073	1.000	
% TA non-credit	0.107	-0.278	0.267	-0.453	-0.225	1.000
Tot. instruct. FTE (log)	0.524	-0.179	0.064	-0.135	0.286	0.088
Direct instruct. exp. (log)	-0.181	0.414	-0.254	0.146	-0.184	-0.383
Research exp. (log)	0.057	0.087	-0.182	0.209	-0.041	-0.186
Org. class TTT_UND (log	-0.196	-0.186	-0.145	0.269	0.221	-0.158
Class size UND (log)	0.266	0.130	-0.024	-0.183	-0.118	0.192
Service field	0.106	-0.023	-0.094	-0.311	0.309	0.218
STEM	-0.272	0.153	-0.129	0.165	-0.219	-0.094
Social Sciences	0.295	-0.013	-0.052	-0.038	0.008	0.114
Humanities	-0.130	-0.173	0.146	-0.156	0.259	0.053
Business Management	0.258	0.022	0.103	0.011	-0.032	-0.120
Proxy for qual. (log)	0.207	0.515	-0.138	-0.162	-0.157	-0.275
Inst. qual. score (log)	-0.147	0.246	-0.191	-0.097	0.044	-0.104

	Tot. instruct. FTE (log)	Direct instruct. exp. (log)	Research exp. (log)	Org. class TTT_UND (log)	Class size UND (log)	Service field
Tot. instruct. FTE (log)	1.000					
Direct instruct. exp. (log)	0.018	1.000				
Research exp. (log)	-0.056	0.172	1.000			
Org. class TTT_UND (log	-0.311	-0.274	-0.060	1.000		
Class size UND (log)	0.155	-0.341	0.131	-0.458	1.000	
Service field	0.432	-0.340	-0.282	0.000	0.251	1.000
STEM	-0.093	0.383	0.493	-0.068	0.040	-0.229
Social Sciences	0.026	-0.188	-0.100	-0.009	0.017	0.064
Humanities	0.088	-0.278	-0.483	0.188	-0.132	0.338
Business Management	-0.016	0.066	0.046	-0.194	0.131	-0.272
Proxy for qual. (log)	0.124	0.449	0.136	-0.470	0.317	-0.109
Inst. qual. score (log)	0.043	0.299	-0.126	-0.288	0.138	0.004

	STEM	Social Sciences	Humanities	Business Management	Proxy for qual. (log)	Inst. qual. score (log)
STEM	1.000					
Social Sciences	-0.522	1.000				
Humanities	-0.494	-0.354	1.000			
Business Management	-0.207	-0.148	-0.140	1.000		
Proxy for qual. (log)	0.052	-0.012	-0.266	0.416	1.000	

Inst. qual. score (log)	-0.011	-0.023	0.029	0.015	0.165	1.000

(log) variables use the natural logarithm

Table 5

Master's Degrees - Correlation Table

	Master's degrees (log)	% Tenured/ tenure track	% Non-tenure track	% Part-time	% TA credit	% TA non-credit
Master's degrees (log)	1.000					
% Tenured/tenure track	0.018	1.000				
% Non-tenure track	0.164	-0.436	1.000			
% Part-time	0.023	-0.284	-0.320	1.000		
% TA credit	-0.106	-0.328	-0.206	-0.048	1.000	
% TA non-credit	-0.100	-0.365	0.281	-0.440	-0.242	1.000
Tot. instruct. FTE (log)	0.332	-0.200	0.100	-0.097	0.328	-0.004
Direct instruct. exp. (log)	0.271	0.399	-0.210	0.119	-0.233	-0.289
Research exp. (log)	0.124	0.037	-0.156	0.284	-0.045	-0.201
Org. sec. TTT_ GRAD (log)	0.078	-0.206	0.162	0.148	-0.132	0.093
Class size GRAD (log)	0.466	0.072	0.130	-0.152	-0.031	-0.010
STEM	-0.051	0.157	-0.085	0.191	-0.250	-0.131
Social Sciences	0.127	-0.036	-0.082	-0.049	0.026	0.156
Humanities	-0.195	-0.156	0.139	-0.175	0.280	0.035
Business Management	0.235	0.015	0.107	0.000	-0.020	-0.099
Proxy for qual. (log)	0.347	0.486	-0.105	-0.191	-0.123	-0.246
Inst. qual. score (log)	0.066	0.235	-0.156	-0.096	0.036	-0.111

	Tot. instruct. FTE (log)	Direct instruct. exp. (log)	Research exp. (log)	Org. sec. TTT_ GRAD (log)	Class size GRAD (log)	STEM
Tot. instruct. FTE (log)	1.000					
Direct instruct. exp. (log)	-0.111	1.000				

Research exp. (log)	-0.048	0.030	1.000			
Org. sec. TTT_ GRAD (log)	-0.270	0.166	-0.057	1.000		
Class size GRAD (log)	0.185	0.045	0.013	-0.253	1.000	
STEM	-0.092	0.349	0.398	0.088	-0.195	1.000
Social Sciences	-0.075	-0.117	-0.052	0.134	0.178	-0.572
Humanities	0.176	-0.303	-0.454	-0.257	-0.106	-0.473
Business Management	0.034	0.031	0.071	0.012	0.291	-0.191
Proxy for qual. (log)	0.135	0.405	0.123	-0.184	0.437	0.041
Inst. qual. score (log)	0.061	0.292	-0.185	-0.150	0.133	0.020

	Social Sciences	Humanities	Business Management	Proxy for qual. (log)	Inst. qual. score (log)
Social Sciences	1.000				
Humanities	-0.345	1.000			
Business Management	-0.139	-0.115	1.000		
Proxy for qual. (log)	0.013	-0.247	0.374	1.000	
Inst. qual. score (log)	-0.068	0.041	0.021	0.180	1.000

(log) variables use the natural logarithm

Table 6

Doctoral Degrees - Correlation Table

	Doctoral degrees (log)	% Tenured/ tenure track	% Non-tenure track	% Part-time	% TA credit	% TA non-credit
Doctoral degrees (log)	1.000					
% Tenured/tenure track	0.064	1.000				
% Non-tenure track	-0.045	-0.424	1.000			
% Part-time	-0.075	-0.302	-0.314	1.000		
% TA credit	0.111	-0.369	-0.221	-0.036	1.000	
% TA non-credit	-0.073	-0.349	0.342	-0.465	-0.224	1.000
Tot. instruct. FTE (log)	0.497	-0.249	0.142	-0.136	0.320	0.084
Direct instruct. exp. (log)	0.178	0.437	-0.176	0.121	-0.245	-0.386

Research exp. (log)	0.129	0.038	-0.216	0.293	-0.027	-0.196
Org. sec. TTT_ GRAD (log)	-0.003	-0.215	0.189	0.142	-0.086	0.060
Class size GRAD (log)	0.185	0.008	0.144	-0.151	-0.039	0.084
STEM	0.104	0.157	-0.076	0.220	-0.274	-0.157
Social Sciences	0.045	-0.042	-0.068	-0.073	0.088	0.121
Humanities	-0.171	-0.159	0.101	-0.174	0.281	0.074
Business Management	-0.027	0.027	0.188	-0.049	-0.104	-0.041
Proxy for qual. (log)	0.261	0.517	-0.089	-0.256	-0.135	-0.229
Inst. qual. score (log)	0.184	0.271	-0.136	-0.117	-0.023	-0.110

	Tot. instruct. FTE (log)	Direct instruct. exp. (log)	Research exp. (log)	Org. sec. TTT_ GRAD (log)	Class size GRAD (log)	STEM
Tot. instruct. FTE (log)	1.000					
Direct instruct. exp. (log)	-0.128	1.000				
Research exp. (log)	-0.116	0.028	1.000			
Org. sec. TTT_ GRAD (log)	-0.265	0.151	-0.070	1.000		
Class size GRAD (log)	0.266	0.032	-0.053	-0.279	1.000	
STEM	-0.191	0.372	0.430	0.113	-0.206	1.000
Social Sciences	-0.016	-0.174	-0.102	0.097	0.206	-0.619
Humanities	0.205	-0.275	-0.407	-0.232	-0.073	-0.491
Business Management	0.134	0.021	-0.035	-0.046	0.259	-0.151
Proxy for qual. (log)	0.201	0.392	0.057	-0.236	0.420	0.043
Inst. qual. score (log)	0.008	0.307	-0.257	-0.131	0.156	-0.023

	Social Sciences	Humanities	Business Management	Proxy for qual. (log)	Inst. qual. score (log)
Social Sciences	1.000				
Humanities	-0.319	1.000			
Business Management	-0.098	-0.078	1.000		
Proxy for qual. (log)	0.035	-0.196	0.275	1.000	
Inst. qual. score (log)	-0.047	0.086	-0.010	0.197	1.000

(log) variables use the natural logarithm

Determining the Estimation Method: OLS Vis-À-Vis SUR

As indicated in the previous chapter, the advantage of the SUR method via FGLS is to improve the efficiency of the parameters estimates when contemporaneous correlation is present across equations. To test for this condition, this study employed the Lagrange multiplier (LM) statistic, as suggested by Breusch and Pagan (1980). The LM statistic tests for independence across equations and is

$$\lambda_{LM} = N \sum_{i=1}^{M} \sum_{j=1}^{i-1} r_{ij}^{2} .$$

For a system of three equations, as it is the case in this study, the LM statistic can be represented as:

$$(\lambda_{LM}) = N \, ({r^2}_{21} + {r^2}_{31} + {r^2}_{32}) ,$$

where $({r^2}_{ij})$ is the squared correlation; that is,

$${r^2}_{ij} = {\sigma^2}_{ij} / \sigma_{ii} \, \sigma_{jj} .$$

The null hypothesis for the Breusch-Pagan test in this study is stated as:

$$H_0\text{: } \sigma_{21} = \sigma_{31} = \sigma_{32} = 0 ,$$

against the alternative hypothesis:

H_1 = at least one covariance is nonzero .

Under the null hypothesis, λ has a chi-squared distribution (x^2) with 3 degrees of freedom.

Table 7 summarizes general results obtained after estimating equations (2), (3), and (4) via the SUR method. As a reminder from chapter three, equations (2), (3), and (4) represent the equations for bachelor’s degrees, master’s degrees, and doctoral degrees respectively without including the two specific quality variables (proxy for quality & institutional quality score). Equations (5) through (13), which include the specific quality variables, were also examined accordingly via the SUR method; their results are reported later in this segment. Table 7 indicates that a total of 189 observations were used for this estimation. The number of observations is smaller than the original samples (235 for bachelor's degrees, 248 for master's degrees, and 213 for doctoral degrees) due to missing values when simultaneous estimations of the three equations was performed. Moreover, Table 7 provides a goodness of fit statistic (R-sq) for each equation and a test for joint significance of all of the regressors within each equation. Table 8 is a correlation matrix of the residuals obtained after simultaneous estimation of equations (2), (3), and (4). Table 8 shows a correlation of .18 between master's degrees [equation (3)] and bachelor's degrees [equation (2)], a correlation of .08 between doctoral degrees [equation (4)] and bachelor's degrees [equation (2)], and a correlation of .13 between doctoral degrees [equation (4)] and master's degrees [equation (3)].

From Table 7 and Table 8, the Breusch-Pagan test of independence, as applied to the equations in this study, rejects (at the .05 alpha level) the null hypothesis that residuals of the three equations are independent (${x^2}_{(3)}$ = 10.630, p = 0.0139). That is, employing the formula above:

$$(\lambda_{LM}) = N\,({r^2}_{21} + {r^2}_{31} + {r^2}_{32})$$

$$= N\,(({.1780\,)^2}_{21} + (\,.0841)^2{}_{31} + (.1323)^2{}_{32})$$

$$= 189\,((.0316) + (.0074) + (.0175))$$

$$= 10.678$$

where 10.678 is significant (at the .05 alpha level) on a chi-squared distribution (x^2) with 3 degrees of freedom.[8] This means that error correlation across equations (2), (3), and (4) is statistically significant at the .05 alpha level. Similar results were found for equations (5) through (13) respectively where error correlation was statistically significant at the .05 alpha level.

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[8] This value varies from 10.630 in the decimal points because it represents a hand calculation while 10.630 was obtained with a computer software.

Equations (5), (8), and (11) (equations for bachelor's degrees, master's degrees, and doctoral degrees respectively where the variable proxy for quality was included) yielded $x^2{}_{(3)}$ = 11.196 with p = .0107. Equations (6), (9), and (12) (equations for bachelor's degrees, master's degrees, and doctoral degrees respectively where the variable institutional quality score was included instead of proxy for quality) yielded $x^2{}_{(3)}$ = 14.221 with p = .0026. And, equations and (7), (10), and (13) (equations for bachelor's degrees, master's degrees, and doctoral degrees respectively where both the variable proxy for quality and the variable institutional quality score were included) yielded $x^2{}_{(3)}$ = 14.762 with p = .0020.

Due to the statistically significant correlation of residuals across equations, (2) to (13) respectively, this study employs the SUR method to take into account contemporaneous correlation within the estimation procedure, which would be otherwise ignored if the equations were estimated via equation-by-equation OLS. As indicated in chapter three, equations (2), (5), (6), and (7) are estimated to examine the production of bachelor's degrees; equations (3), (8), (9), and (10) are estimated to examine the production of master's degrees; and equations (4), (11), (12), and (13) are estimated to examine the production of doctoral degrees (see Appendix F).[9] Within each degree type (i.e. bachelor's degrees, master's degrees and doctoral degrees), the first equation [equations (2), (3), & (4) respectively] uses research expenditures per tenured/tenure track faculty as a control for quality, the second equation [equations (5), (8), & (11) respectively] adds a proxy for quality to the model, the third equation [equations (6), (9), & (12) respectively] uses an institutional quality score instead of the proxy for quality, and the fourth equation [equations (7), (10), & (13) respectively] includes both the proxy for quality and the institutional quality score to examine their joint effect on degree production. The SUR estimation is

[9] Equations (2) to (13) include the specific equations to be examined in this study, equation (1) is not included here because it is not a specific equation but rather a representation of the general model for this study.

conducted according to these latter four groupings [i.e. equations (2), (3), & (4) and so forth] where equations within each group are estimated simultaneously, one equation for each degree type (see Appendix G); however, the results of this estimation are reported in the respective tables in this chapter by degree type.

Table 7

Summary of Estimating Equations (2), (3), & (4) via the SUR Method

Equation	Obs.	Parameters	RMSE	R-sq	chi2	P
Bachelor's degrees	189	13	.827	0.553	233.19	0.000
Master's degrees	189	12	.720	0.532	214.78	0.000
Doctoral degrees	189	12	.560	0.503	192.68	0.000

Table 8

Correlation Matrix of Residuals when Estimating Equations (2), (3), & (4) via the SUR Method

	Bachelor's degrees	Master's degrees	Doctoral degrees
Bachelor's degrees	1.0000		
Master's degrees	0.1780	1.0000	
Doctoral degrees	0.0841	0.1323	1.0000

Examining the Research Questions and Hypotheses

The purpose of this study is to examine degree production in public research universities in the United States by analyzing the association between departmental factors in academic units and the number of degrees conferred by these units taking into consideration quality and field of study. As such, this study explores three research questions, which were introduced in chapter one:

1. How are departmental factors in academic units such as instructional type (i.e. mix of tenured/tenure track faculty, adjunct faculty, and graduate assistants); size (i.e. total instructional FTE); and financial resources (i.e. instructional expenditures and research expenditures) associated with the production of bachelor's degrees, master's degrees, and doctoral degrees, taking into account quality and field of study?

2. What departmental factors (i.e. instructional type, size, and financial resources) in academic units achieve the greatest number of graduates taking into account quality and field of study?

3. How does the production of bachelor's degrees, master's degrees, and doctoral degrees vary across academic fields after holding constant quality and the respective departmental factors?

In addition, this study examines six hypotheses that were elaborated in chapter two:

Hypothesis 1: An increase in the amount of inputs in the production process of degrees should yield an increase in the number of degrees produced controlling for quality.

Hypothesis 2: Tenured/tenure track faculty involved in instruction at an academic department might actually produce fewer bachelor's degrees than the other instructional types (i.e. adjunct faculty and graduate assistants).

Hypothesis 3: Tenured/tenure track faculty involved in instruction at an academic department should produce more master's degrees and doctoral degrees than the other instructional types (i.e. adjunct faculty involved in instruction for producing both master's degrees and doctoral degrees and graduate assistants involved in instruction for producing master's degrees).

Hypothesis 4: Fields of study closer to the market should be able to generate more bachelor's degrees and master's degrees due to the attractiveness of their programs in relation to the knowledge-intensive economy.

Hypothesis 5: Fields of study closer to the federal research market should be able to generate more doctoral degrees than other fields due to the emphasis academic departments place in competing for contracts and grants in such market.

Hypothesis 6: Funding from contracts and grants should have a significant and positive effect on the production of doctoral degrees due to the financial support that these funds provide for graduate students.

To answer the research questions and examine the hypotheses, SUR estimation is employed for equations (2) through (13) (see Appendix G). Having estimated these equations and analyzed the results, the coefficients are then standardized to further examine research question two. In addition, a more detailed examination of the coefficients for the dummy variables representing the various fields of study is conducted to supplement the analysis of research question three and hypotheses four and five. Each of the analyses is performed by type of degree (i.e. bachelor's degrees, master's degrees, and doctoral degrees).

Analyzing Equations (2) through (13) via SUR Estimation

This section analyzes the results of estimating equations (2) through (13) via the SUR method. The SUR estimation is performed according to the four groupings shown in Appendix G. However, the analysis in this section is separated by degree level in order to compared equations across within each degree type. Equations (2), (5), (6), and (7) are examined for bachelor's degrees; equations (3), (8), (9), and (10) are examined for master's degrees; and equations (4), (11), (12), and (13) are examined for doctoral degrees (see Appendix F). In all of the equations the percentage of tenured/tenure track faculty and the field of business management constitute reference categories respectively. Robust standard errors obtained via bootstrapping are employed for the various equations to account for heteroskedasticity.

Bachelor's Degrees

Table 9 presents the results of equations (2), (5), (6), and (7). As previously indicated, these four equations are estimated as different alternatives to account for quality. Equation (2) uses research expenditures per tenured/tenure track faculty [Research exp. (log)] as a control for quality. Equation (5) adds an approximation of average faculty salary [Proxy for qual. (log)] as a proxy for quality. Equation (6) uses the *U.S. News* institutional quality score [Inst. qual. score (log)] instead of the proxy for quality and equation (7) employs both the proxy for quality and the institutional quality score to account for quality (see Appendix F).

Table 9 shows that the significance of the coefficients varies by equation with the exception of total instructional FTE [Tot. instruct. FTE (log)] and organized class sections taught per tenured/tenure track faculty at the undergraduate level [Org. class TTT_UND (log)] where the former is significant at the 1% level while the latter is significant at the 5% level. Moreover, the proxy for quality and institutional quality score are not significant in any of the equations where these variables are introduced. Concerning the signs of the coefficients, they remain the same in all four equations except for the percentage of non-credit bearing teaching assistants (% TA non-credit), which is negative in equations (2) and (6) and positive in equations (5) and (7). However, this coefficient is not significant. Although there are some differences in the magnitude of the coefficients across equations, these are minor for the continuous variables and somewhat more pronounced for the dummy variables representing the various fields of study. Overall, the variables remain stable in significance, sign, and magnitude across all four equations.

Examining the specific variables of interest (i.e. instructional type, size, and financial resources), Table 9 indicates that the only variable that shows some significance for instructional type is the percentage of credit bearing teaching assistants (% TA credit), which is significant at the 10% level in equations (2), (5), and (6).[10] As such, these coefficients (% TA credit) respectively indicate that the percentage of credit bearing teaching assistants produce fewer degrees than the percentage of tenured/tenure track faculty, the reference category, per CIP net of all of the other variables in the model.

When looking at size, as measured by total instructional FTE [Tot. instruct. FTE (log)], the positive signs of the coefficients imply an increasing marginal effect. More specifically, a 10% increase in size leads, approximately, to a 10% increase in baccalaureate degree production net of all of the other variables in the model.[11] Moving on to the financial variables, Table 9 indicates that the measure for direct instructional expenditures [Direct instruct. exp. (log)] is not significant across all four equations while research expenditures per tenured/tenure track faculty [Research exp. (log)] is significant in only two equations [equations (2) and (5)]. However, its significance is marginal (significance at the 10% level).

As far as the control variables, organized class sections taught per tenured/tenure track faculty at the undergraduate level [Org. class TTT_UND (log)] is significant at the 5% level and has a positive sign indicating that a 10% increase in the average number of classes taught by tenured/tenure track faculty at the undergraduate level results in, approximately, a 4% increase in bachelor's degrees net of all of the other variables in the model. Moreover, class size at the undergraduate level [Class size UND (log)] shows some signs of significance indicating a positive marginal effect on the production of bachelor's degrees.

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[10] Coefficients with a p-value above .05 and below .10 are marked with a (+) in all of the tables and are reported as an indication of marginal significance.

[11] The interpretation for a double-log model is: $\%\Delta\gamma = \beta_1\%\Delta\chi$ holding everything else constant (Wooldridge, 2006). Hence, for every 1% increase in the independent variable, the dependent variable increases or decreases (depending on the sign) in percentages by the beta coefficient. This particular study interprets the beta coefficients of the logged variables by using 10% rather than 1%; thus, the beta coefficient is multiplied by 10% instead of 1%.

Table 9

Bachelor's Degrees - SUR Regression Results of Equations (2), (5), (6), & (7)

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
% Non-tenure track	0.012 [0.010]	0.013 [0.010]	0.010 [0.010]	0.012 [0.010]
% Part-time	0.0004 [0.006]	0.006 [0.007]	0.001 [0.006]	0.005 [0.007]
% TA credit	-0.016 [0.008]+	-0.014 [0.008]+	-0.015 [0.008]+	-0.013 [0.008]
% TA non-credit	-0.002 [0.008]	0.004 [0.009]	-0.002 [0.008]	0.003 [0.009]
Tot. instruct. FTE (log)	1.043 [0.118]**	1.007 [0.116]**	1.009 [0.118]**	0.985 [0.116]**
Direct instruct. exp. (log)	-0.165 [0.240]	-0.304 [0.262]	-0.081 [0.249]	-0.211 [0.280]
Research exp. (log)	0.046 [0.025]+	0.045 [0.025]+	0.038 [0.024]	0.039 [0.025]
Org. class TTT_UND (log)	0.395 [0.189]*	0.396 [0.190]*	0.362 [0.183]*	0.369 [0.186]*
Class size UND (log)	0.345 [0.188]+	0.241 [0.199]	0.395 [0.188]*	0.302 [0.205]
Service field	-0.299 [0.228]	-0.276 [0.222]	-0.294 [0.225]	-0.275 [0.221]
STEM	-1.326 [0.596]*	-1.118 [0.654]+	-1.385 [0.585]*	-1.202 [0.646]+
Social Sciences	-0.180 [0.610]	-0.009 [0.659]	-0.230 [0.598]	-0.079 [0.647]

Table 9

(Continued)

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
Humanities	-1.054 [0.610]+	-0.841 [0.669]	-1.072 [0.595]+	-0.891 [0.655]
Proxy for qual. (log)		0.506 [0.309]		0.418 [0.321]
Inst. qual. score (log)			-0.488 [0.331]	-0.377 [0.345]
Constant	0.548 [2.437]	-4.072 [3.841]	1.975 [2.374]	-2.197 [4.062]
Observations	189	189	189	189
R-squared	.55	.56	.55	.56

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%
(log) variables use the natural logarithm

Analyzing the dummy variables representative of the fields of study, Table 9 shows that STEM is significant across all four equations, the field of humanities is marginally significant in only two equations, and social sciences is not significant in any of the equations. The negative signs for STEM and humanities are an indication that these fields produce fewer bachelor's degrees than business management (the reference category) net of all of the other variables in the model. A more detailed examination of this matter is provided later in this chapter.

Master's Degrees

Table 10 presents the results of equations (3), (8), (9), and (10) where, similar to the previous analysis, equation (3) uses research expenditures per tenured/tenure track faculty [Research exp. (log)] as a control for quality, equation (8) adds an approximation of average faculty salary [Proxy for qual. (log)] as a proxy for quality, equation (9) uses the *U.S. News* institutional quality score [Inst. qual. score (log)] instead of the proxy for quality and equation (10) employs both the proxy for quality and the institutional quality score to account for quality (see Appendix F).

Table 10 shows that for the most part, significance remains constant across all four equations except for the percentage of non-credit bearing teaching assistants (% TA non-credit). Concerning the quality variables [Proxy for qual. (log) & Inst. qual. Score (log)], they are not significant in any of the equations where they are introduced as it is the case with the analysis of bachelor's degrees (see Table 9). The signs of the coefficients also remain constant across all four equations except for the percentage of part-time faculty (% Part-time). The sign of this variable is positive in equations (3) and (9) and negative in equations (8) and (10). However, none of the coefficients for this variable is significant. The magnitude of the coefficients, overall, remains somewhat stable across all four equations.

Examining the specific variables on interest, (i.e. instructional type, size, and financial resources), Table 10 shows that for instructional type, only the percentage of credit bearing teaching assistants (% TA credit) is consistently significant (significance at the 5% level) across all four equations. This variable has a negative sign indicating, as such, that this instructional type produces fewer master's degrees than the reference category tenured/tenure track faculty. The variable for size [Tot. instruct. FTE (log)] in Table 10, similar to the analysis for bachelor's degrees, shows a significant positive relationship with the dependent variable. The coefficients for this variable indicate that a 10% increase in total instructional FTE increases the number of master's degrees, approximately, by 6% net of all of the other variables in the model. A similar relationship is observed, from Table 10, for the first financial variable [Direct instruct. exp. (log)]. The coefficients for direct instructional expenditures are significant at the 1% level and positive; hence, a 10% increase in this variable increases master's degree production, approximately, by 5% net of all of the other variables in the model. The coefficients for research expenditures per tenured/tenure track faculty [Research exp. (log)] are marginally significant (significance at the 10% level) and positive across all four equations indicating that a 10% increase in this variable increases the production of master's degrees by .37% net of all of the other variables in the model.

Concerning the control variables, organized class sections taught per tenured/tenure track faculty at the graduate level [Org. sec. TTT _GRAD (log)] is significant at the 5% level across all four equations. In addition, class size at the graduate level [Class size GRAD (log)] is consistently significant at the 1% level across all four equations. Both of these variables show a positive effect on the production of masters' degrees where a 10% increase results, approximately, in a 3% and 6% increase respectively in master's degree production net of all of the other variables in the model. As far as the fields of study, a clear trend is observed; business management (the reference category) consistently produces more master's degrees than STEM, social sciences, and humanities net of all of the other variables in the model.

Table 10

Master's Degrees - SUR Regression Results of Equations (3), (8), (9), & (10)

	Equation (3)	Equation (8)	Equation (9)	(Equation 10)
% Non-tenure track	0.008 [0.007]	0.007 [0.007]	0.008 [0.006]	0.007 [0.007]
% Part-time	0.001 [0.006]	-0.001 [0.006]	0.001 [0.006]	-0.001 [0.006]
% TA credit	-0.016 [0.006]**	-0.017 [0.006]**	-0.016 [0.006]**	-0.017 [0.006]**
% TA non-credit	-0.013 [0.008]	-0.015 [0.008]+	-0.013 [0.008]	-0.015 [0.008]+
Tot. instruct. FTE (log)	0.596 [0.095]**	0.606 [0.102]**	0.593 [0.096]**	0.604 [0.103]**
Direct instruct. exp. (log)	0.465 [0.154]**	0.481 [0.153]**	0.473 [0.157]**	0.493 [0.157]**
Research exp. (log)	0.037 [0.021]+	0.037 [0.021]+	0.036 [0.021]+	0.036 [0.021]+
Org. sec. TTT_ GRAD (log)	0.311 [0.133]*	0.319 [0.136]*	0.310 [0.134]*	0.317 [0.137]*
Class size GRAD (log)	0.607 [0.141]**	0.645 [0.151]**	0.612 [0.142]**	0.651 [0.152]**
STEM	-1.182 [0.237]**	-1.215 [0.248]**	-1.185 [0.237]**	-1.222 [0.248]**
Social Sciences	-0.905 [0.232]**	-0.943 [0.245]**	-0.909 [0.232]**	-0.950 [0.245]**

Table 10

(Continued)

	Equation (3)	Equation (8)	Equation (9)	(Equation 10)
Humanities	-0.992 [0.275]**	-1.039 [0.295]**	-0.994 [0.274]**	-1.045 [0.293]**
Proxy for qual. (log)		-0.148 [0.220]		-0.154 [0.222]
Inst. qual. score (log)			-0.073 [0.270]	-0.087 [0.271]
Constant	-2.948 [1.022]**	-1.441 [2.549]	-2.703 [1.339]*	-1.086 [2.727]
Observations	189	189	189	189
R-squared	.53	.53	.53	.53

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%
(log) variables use the natural logarithm

Doctoral Degrees

Table 11 presents the results of equations (4), (11), (12), and (13) where, similar to the previous two analyses, equation (4) uses research expenditures per tenured/tenure track faculty [Research exp. (log)] as a control for quality, equation (11) adds an approximation of average faculty salary [Proxy for qual. (log)] as a proxy for quality, equation (12) uses the *U.S. News* institutional quality score [Inst. qual. Score(log)] instead of the proxy for quality and equation (13) employs both the proxy for quality and the institutional quality score to account for quality (see Appendix F).

Table 11 shows that although certain trend can be seen concerning the significance of the variables overall, some coefficients vary in their significance by equation. The percentage of non-tenure track faculty [% Non-tenure track], for example, is significant at the 1% level in equation (4), significant at the 5% level in equations (11) and (12), and significant at the 10% level in equation (13). The percentage of part-time faculty (% Part-time), on the other hand maintains its significance at the 1% and 5% levels respectively. Concerning the signs of the coefficients, they remain constant across all four equations except for direct instructional expenditures [Direct instruct. exp. (log)], which shows a positive sign in equation (4) and negative signs in equations (11), (12), and (13); nonetheless, this variable is not significant in any of the four equations. In regard to the magnitude, the coefficients show certain stability for the most part.

In addition, Table 11 shows that similarly to the two previous analyses (bachelor's degrees and master's degrees) the proxy for quality [Proxy for qual. (log)] is not significant in any of the equations where it is introduced [equations (11) & (13)]. However, differently from the two previous analyses, the variable institutional quality score [Inst. qual. score (log)] is significant at the 1% level in both of the equations where it is included [equations (12) & (13)].

Examining the specific variables of interest, (i.e. instructional type, size, and financial resources), Table 11 shows that the instructional type variables are consistently significant and negative indicating that the percentage of tenured/tenure track faculty, the reference category, produces more doctoral degrees than all other instructional types. On average, a one percentage point increase in either non-tenure track or part-time faculty leads to, approximately, a 1% to 1.5% decrease in doctoral degree production relative to tenured/tenure track faculty net of all of the other variables in the model.

The variable for size in Table 11 [Tot. instruct. FTE (log)], similarly to the analysis for bachelor's degrees and master's degrees, shows a significant positive relationship with the dependent variable across all four equations. As such, a 10% increase in total instructional FTE increases the number of doctoral degrees, approximately, by 8% net of all of the other variables in the model. The variable for direct instructional expenditures [Direct instruct. exp. (log)], similarly to bachelor's degrees and unlike master's degrees, does not show any significance across any of the four equations. Research expenditures per tenured/tenure track faculty, on the other hand, shows a significant and positive effect on the production of doctoral degrees across all four equations. More specifically, for every 10% increase in research expenditures per tenured/tenure track faculty, doctoral degree production increases by approximately .4% to .6 % net of all of the other variables in the model.

From the control variables, only organized class sections taught per tenured/tenure track faculty at the graduate level [Org. class sec. TTT (GRAD)] is significant, and, it has a positive sign indicating a positive effect on doctoral degree production net of all of the other variables in the model. Concerning the dummy variables representing the different fields of study, the coefficients are marginally significant and positive for STEM and social sciences. This is an indication that these fields produce more doctoral degrees than the field of business management (the reference category) net of all of the other variables in the model. As previously mentioned, a more detailed examination of this matter is provided later in this chapter. Lastly, from the quality variables, only the institutional quality score [(Inst. qual. score (log)] is significant. The positive

Table 11

Doctoral Degrees - SUR Regression Results of Equations (4), (11), (12), & (13)

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
% Non-tenure track	-0.015 [0.005]**	-0.014 [0.005]*	-0.012 [0.005]*	-0.009 [0.006]+
% Part-time	-0.014 [0.004]**	-0.012 [0.005]*	-0.013 [0.003]**	-0.010 [0.004]*
% TA credit	-0.010 [0.005]*	-0.009 [0.005]	-0.011 [0.005]*	-0.008 [0.005]+
% TA non-credit	-0.015 [0.006]**	-0.013 [0.006]*	-0.015 [0.005]**	-0.011 [0.006]+
Tot. instruct. FTE (log)	0.788 [0.075]**	0.773 [0.078]**	0.826 [0.071]**	0.805 [0.073]**
Direct instruct. exp. (log)	0.018 [0.122]	-0.006 [0.121]	-0.114 [0.117]	-0.151 [0.116]
Research exp. (log)	0.041 [0.013]**	0.041 [0.013]**	0.059 [0.013]**	0.059 [0.013]**
Org. sec. TTT_ GRAD (log)	0.137 [0.077]+	0.135 [0.079]+	0.175 [0.070]*	0.171 [0.071]*
Class size GRAD (log)	-0.004 [0.097]	-0.040 [0.109]	-0.075 [0.096]	-0.127 [0.105]
STEM	0.520 [0.289]+	0.576 [0.309]+	0.574 [0.299]+	0.655 [0.329]*
Social Sciences	0.460 [0.283]	0.518 [0.301]+	0.519 [0.291]+	0.604 [0.320]+

Table 11

(Continued)

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
Humanities	0.249 [0.315]	0.325 [0.331]	0.285 [0.325]	0.394 [0.350]
Proxy for qual. (log)		0.193 [0.204]		0.274 [0.186]
Inst. qual. score (log)			1.039 [0.208]**	1.061 [0.210]**
Constant	-1.183 [0.839]	-3.178 [2.324]	-4.642 [1.035]**	-7.557 [2.330]**
Observations	189	189	189	189
R-squared	.50	.51	.57	.57

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%
(log) variables use the natural logarithm

coefficients of this variable indicates that a 10% increase in the institutional quality score increases the number of doctoral degrees by approximately 10% net of all of the other variables in the model.

Analyzing the Standardized Coefficients

To further examine research two, this section analyzes the standardized coefficients of equations (2) through (13). Examining standardized coefficients helps complement research question two by standardizing the scale of the regressors, and as such, placing the explanatory variables on equal footing. Given the nature of research question two, the significant coefficients with a positive sign are compared in their magnitude to determine which achieves the greatest number of graduates. As previously indicated the analysis is conducted by degree type. In each of the tables, the point estimate is presented in the first row while the standardized coefficient is presented in the second row. The (+), (*), and (**) signs denoting significance are placed next to the standardized coefficients only.

Bachelor's Degrees

Table 12 shows that out of the statistically significant coefficients those with a positive sign include total instructional FTE [Tot. instruct. FTE (log)], organized class sections taught per tenured/tenure track at the undergraduate level [Org. class TTT_UND (log)], class size at the undergraduate level [Class size UND (log)], and research expenditures per tenured/tenure track faculty [Research exp. (log)]. From these, total instructional FTE shows the largest values (.591 to .626) across all four equations. Total instructional FTE is followed by organized class sections taught per tenured/tenure track at the undergraduate level (.203 to .217) in equations (2), (5), and (7). Total instructional FTE and organized class sections taught per tenured/tenure track at the undergraduate level are followed by class size at the undergraduate level and research expenditures per tenured/tenure track faculty in equation (2) and by research expenditures per tenured/tenure track faculty in equation (5). In equation (6), total instructional FTE is followed

Table 12

Bachelor's Degrees - Standardized Coefficients of Equations (2), (5), (6), & (7)

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
% Non-tenure track	0.012 0.096	0.013 0.112	0.010 0.086	0.012 0.102
% Part-time	0.0004 0.005	0.006 0.062	0.001 0.008	0.005 0.055
% TA credit	-0.016 -0.154+	-0.014 -0.135+	-0.015 -0.142+	-0.013 -0.127
% TA non-credit	-0.002 -0.018	0.004 0.037	-0.002 -0.021	0.003 0.025
Tot. instruct. FTE (log)	1.043 0.626**	1.007 0.604**	1.009 0.606**	0.985 0.591**
Direct instruct. exp. (log)	-0.165 -0.073	-0.304 -0.133	-0.081 -0.036	-0.211 -0.093
Research exp. (log)	0.046 0.153+	0.045 0.152+	0.038 0.126	0.039 0.131
Org. class TTT_UND (log)	0.395 0.217*	0.396 0.218*	0.362 0.199*	0.369 0.203*
Class size UND (log)	0.345 0.196+	0.241 0.137	0.395 0.225*	0.302 0.172
Service field	-0.299 -0.118	-0.276 -0.109	-0.294 -0.117	-0.275 -0.109
STEM	-1.326 -0.536*	-1.118 -0.452+	-1.385 -0.560*	-1.202 -0.485+
Social Sciences	-0.180 -0.063	-0.009 -0.003	-0.230 -0.081	-0.079 -0.028

Table 12

(Continued)

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
Humanities	-1.054 -0.357+	-0.841 -0.285	-1.072 -0.363+	-0.891 -0.302
Proxy for qual. (log)		0.506 0.139		0.418 0.114
Inst. qual. score (log)			-0.488 -0.090	-0.377 -0.069
Constant	0.548 0.441	-4.072 -3.281	1.975 1.591	-2.197 -1.770
Observations	189	189	189	189
R-squared	.55	.56	.55	.56

Point estimate in first row
Normalized/Standardized beta coefficients in second row
+ significant at 10%; * significant at 5%; ** significant at 1%
(log) variables use the natural logarithm

by class size and organized class sections taught per tenured/tenure track at the undergraduate level.

Master's Degrees

Table 13 shows a clear trend for master's degrees concerning the coefficients that have the greatest effect on production for this type of degree. That is, out of the statistically significant

Table 13

Master's Degrees - Standardized Coefficients of Equations (3), (8), (9), & (10)

	Equation (3)	Equation (8)	Equation (9)	Equation (10)
% Non-tenure track	0.008 0.081	0.007 0.069	0.008 0.078	0.007 0.065
% Part-time	0.001 0.014	-0.001 -0.010	0.001 0.012	-0.001 -0.012
% TA credit	-0.016 -0.183**	-0.017 -0.197**	-0.016 -0.183**	-0.017 -0.197**
% TA non-credit	-0.013 -0.138	-0.015 -0.160+	-0.013 -0.139	-0.015 -0.161+
Tot. instruct. FTE (log)	0.596 0.420**	0.606 0.428**	0.593 0.419**	0.604 0.426**
Direct instruct. exp. (log)	0.465 0.240**	0.481 0.248**	0.473 0.244**	0.493 0.254**
Research exp. (log)	0.037 0.147+	0.037 0.147+	0.036 0.142+	0.036 0.141+
Org. sec. TTT_ GRAD (log)	0.311 0.230*	0.319 0.236*	0.310 0.230*	0.317 0.235*
Class size GRAD (log)	0.607 0.324**	0.645 0.345**	0.612 0.327**	0.651 0.348**
STEM	-1.182 -0.561**	-1.215 -0.576**	-1.185 -0.562**	-1.222 -0.580**
Social Sciences	-0.905 -0.374**	-0.943 -0.390**	-0.909 -0.376**	-0.950 -0.393**

Table 13

(Continued)

	Equation (3)	Equation (8)	Equation (9)	Equation (10)
Humanities	-0.992 -0.395**	-1.039 -0.414**	-0.994 -0.395**	-1.045 -0.416**
Proxy for qual. (log)		-0.148 -0.048		-0.154 -0.049
Inst. qual. score (log)			-0.073 -0.016	-0.087 -0.019
Constant	-2.948 -2.790**	-1.441 -1.364	-2.703 -2.558*	-1.086 -1.028
Observations	189	189	189	189
R-squared	.53	.53	.53	.53

Point estimate in first row
Normalized/Standardized beta coefficients in second row
+ significant at 10%; * significant at 5%; ** significant at 1%
(log) variables use the natural logarithm

coefficients, total instructional FTE [Tot. instruct. FTE (log)] (.419 to .428) has the greatest effect across all four equations followed by class size at the graduate level [Class size GRAD (log)] (.324 to .348), direct instructional expenditures [Direct instruct. exp. (log)] (.240 to .254), organized class sections taught per tenured/tenure track faculty at the graduate level [Org. sec.

TTT_ GRAD (log)] (.230 to .236), and research expenditures per tenured/tenure track faculty [Research exp. (log)] (.141 to . 147).

Doctoral Degrees

Table 14 shows that out of the statistically significant coefficients, those with a positive sign include total instructional FTE [Tot. instruct. FTE (log)], STEM, social sciences, research expenditures per tenured/tenure track faculty [Research exp. (log)], organized class sections taught per tenured/tenure track faculty at the graduate level [Org. sec. TTT_ GRAD (log)], and institutional quality score [Inst. qual. score (log)]. From these, total instructional FTE (.722 to .772) and STEM (.327 to .411) have the greatest effect respectively across all four equations. Within equation (4), total instructional FTE and STEM are followed by research expenditures per tenured/tenure track faculty and organized class sections taught per tenured/tenure track faculty at the graduate level. Within equation (11), total instructional FTE and STEM are followed by social sciences, research expenditures per tenured/tenure track faculty, and organized class sections taught per tenured/tenure track faculty at the graduate level. Within equation (12), total instructional FTE and STEM are followed by research expenditures per tenured/tenure track faculty, institutional quality score, social sciences, and organized class sections taught per tenured/tenure track faculty at the graduate level. Lastly, within equation (13), total instructional FTE and STEM are followed by social sciences, research expenditures per tenured/tenure track faculty, institutional quality score, and organized class sections taught per tenured/tenure track faculty at the graduate level.

Analyzing the Fields of Study

To supplement the analysis of research question three and hypotheses four and five, this section examines the coefficients of the dummy variables representing the different fields of

Table 14

Doctoral Degrees - Standardized Coefficients of Equations (4), (11), (12), & (13)

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
% Non-tenure track	-0.015 -0.196**	-0.014 -0.177*	-0.012 -0.151*	-0.009 -0.122+
% Part-time	-0.014 -0.240**	-0.012 -0.201*	-0.013 -0.225**	-0.010 -0.168*
% TA credit	-0.010 -0.156*	-0.009 -0.133	-0.011 -0.161*	-0.008 -0.128+
% TA non-credit	-0.015 -0.223**	-0.013 -0.187*	-0.015 -0.213**	-0.011 -0.161+
Tot. instruct. FTE (log)	0.788 0.736**	0.773 0.722**	0.826 0.772**	0.805 0.752**
Direct instruct. exp. (log)	0.018 0.012	-0.006 -0.004	-0.114 -0.078	-0.151 -0.103
Research exp. (log)	0.041 0.213**	0.041 0.213**	0.059 0.305**	0.059 0.306**
Org. sec. TTT_ GRAD (log)	0.137 0.135+	0.135 0.133+	0.175 0.172*	0.171 0.168*
Class size GRAD (log)	-0.004 -0.003	-0.040 -0.029	-0.075 -0.053	-0.127 -0.090
STEM	0.520 0.327+	0.576 0.362+	0.574 0.360+	0.655 0.411*
Social Sciences	0.460 0.252	0.518 0.284+	0.519 0.284+	0.604 0.330+

Table 14

(Continued)

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
Humanities	0.249 0.131	0.325 0.171	0.285 0.150	0.394 0.207
Proxy for qual. (log)		0.193 0.082		0.274 0.117
Inst. qual. score (log)			1.039 0.298**	1.061 0.304**
Constant	-1.183 -1.483	-3.178 -3.982	-4.642 -5.818**	-7.557 -9.471**
Observations	189	189	189	189
R-squared	.50	.51	.57	.57

Point estimate in first row
Normalized/Standardized beta coefficients in second row
+ significant at 10%; * significant at 5%; ** significant at 1%
(log) variables use the natural logarithm

study by estimating equations (2) through (13) with each of the fields as a different reference category. The tables presented in this section include only the coefficients of the dummy variables for the fields of study. The coefficients of the other variables have been omitted from the tables for ease of presentation. However, it is important to point out that the sign, significance, and magnitude of the omitted coefficients are exactly the same, within the various equations, regardless of the category being employed as a reference for field of study. As in the previous two sections this analysis is presented by degree type.

As it relates to the hypotheses, hypothesis four poses that fields closer to the market should be able to generate more bachelor's degrees and master's degrees than the other fields while hypothesis five poses that fields closer to the federal research market should be able to generate more doctoral degrees than the other fields. To examine these propositions, this study borrows from Volk et al.'s (2001) discussion concerning the use of measures to represent an academic department's closeness to the market, as well as, closeness to the federal research market. Volk et al. pointed out that for human capital theorists, closeness to the market was represented by higher salaries and as such Volk et al. employed student exit salary and initial salary of assistant professors as proxies to measure closeness to the market in their study. In addition, as previously indicated, Volk et al. also employed number of grant and contract dollars generated by the various departments to represent closeness to the federal research market. Using this logic, this study, examines hypothesis four by employing the field of business management as the reference category and hypothesis five by examining STEM as the reference category. For the former, it makes intuitive sense that the field of business management would be closer to the market given the emphasis of its curricula. The same could also be said about STEM in regard to its closeness to the federal research market. However, this closeness, respectively, was examined by this study empirically based on the discussion of Volk et al. mentioned above. As such, this study found that the field of business management had the highest mean in average faculty salary than the other fields while STEM had the highest mean in research expenditures per tenured/tenure track faculty. Hence, a reaffirmation of Volk et al.'s discussion and a confirmation for the use of business management and STEM as reference categories respectively to examine hypotheses four and five.

Bachelor's Degrees

Tables 15, 16, 17, and 18 correspond to the analysis for bachelor's degrees. The field of business management constitutes the reference category in Table 15. In Table 15, only STEM shows significance across all four equations. The field of humanities shows some significance in two equations while the field of social sciences does not show any significance. The negative signs of the coefficients are an indication that statistically significant fields of study produce fewer bachelor's degrees than business management (the reference category) net of all of the other variables in the model. In Table 16, STEM is the reference category. Table 16 indicates that social sciences and business management produce more bachelor's degrees than STEM net of all of the other variables in the model. The field of humanities, on the other hand, although it has positive signs, it does not show significance in production differences as compared to STEM. The field of social sciences represents the reference category in Table 17. Table 17 indicates that humanities and STEM produce fewer bachelor's degrees than social sciences net of all of the other variables in the model. Lastly, humanities constitute the reference category in Table 18. In Table 18, the field of social sciences is consistently significant and has positive signs indicating that it produces more bachelor's degrees than humanities net of all of the other variables in the model. For business management, although it has positive signs, it is not consistently significant.

Master's Degrees

Tables 19, 20, 21, and 22 correspond to the analysis for master's degrees. The field of business management constitutes the reference category in Table 19. In Table 19, the coefficients across all four equations are consistently significant at the 1% level and have a negative sign, which firmly indicates that STEM, social sciences, and humanities produce fewer master's degrees than the field of business management net of all of the other variables in the model. In Table 20, STEM is the reference category. Table 20 shows that social sciences and business management produce more master's degrees than STEM net of all of the other variables in the model. The significance of the former, however, is marginal. In Table 21, the field of social sciences constitutes the reference category. In this table, only business management produces more master's degrees than social sciences, net of all other variables in the model, while STEM produces fewer degrees net of all other variables in the model. Lastly, the field of humanities constitutes the reference category in Table 22. In Table 22, business management produces more master's degrees than the field of humanities while the other fields do not show statistical differences in production of master's degrees.

Doctoral Degrees

Tables 23, 24, 25, and 26 correspond to the analysis for doctoral degrees; the majority of the significant coefficients in these tables show marginal significance (significance at the 10% level). The field of business management constitutes the reference category in Table 23. Table 23 shows that overall STEM and social sciences produce more doctoral degrees than business management net of all of the other variables in the model. In Table 24, STEM is the reference category. Table 24 shows that humanities and business management produce fewer doctoral degrees than STEM net of all of the other variables in the model. The field of social sciences constitutes the reference category in Table 25. This table shows that business management produces fewer doctoral degrees than social sciences net of all of the other variables in the model. Finally, in Table 26 the field of humanities is the reference category. This table indicates that STEM produces more doctoral degrees than humanities net of all of the other variables in the model.

Table 15

Bachelor's Degrees - Business Management as Reference Category

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
STEM	-1.326 [0.596]*	-1.118 [0.654]+	-1.385 [0.585]*	-1.202 [0.646]+
Social Sciences	-0.180 [0.610]	-0.009 [0.659]	-0.230 [0.598]	-0.079 [0.647]
Humanities	-1.054 [0.610]+	-0.841 [0.669]	-1.072 [0.595]+	-0.891 [0.655]

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 16

Bachelor's Degrees - STEM as Reference Category

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
Social Sciences	1.146 [0.198]**	1.109 [0.196]**	1.155 [0.199]**	1.123 [0.202]**
Humanities	0.272 [0.242]	0.277 [0.243]	0.314 [0.239]	0.311 [0.242]
Business Management	1.326 [0.596]*	1.118 [0.654]+	1.385 [0.585]*	1.202 [0.646]+

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 17

Bachelor's Degrees - Social Sciences as Reference Category

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
Humanities	-0.874 [0.196]**	-0.831 [0.202]**	-0.842 [0.194]**	-0.813 [0.199]**
Business Management	0.180 [0.610]	0.009 [0.659]	0.230 [0.598]	0.079 [0.647]
STEM	-1.146 [0.198]**	-1.109 [0.196]**	-1.155 [0.199]**	-1.123 [0.202]**

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 18

Bachelor's Degrees- Humanities as Reference Category

	Equation (2)	Equation (5)	Equation (6)	Equation (7)
Business Management	1.054 [0.610]+	0.841 [0.669]	1.072 [0.595]+	0.891 [0.655]
STEM	-0.272 [0.242]	-0.277 [0.243]	-0.314 [0.239]	-0.311 [0.242]
Social Sciences	0.874 [0.196]**	0.831 [0.202]**	0.842 [0.194]**	0.813 [0.199]**

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 19

Master's Degrees - Business Management as Reference Category

	Equation (3)	Equation (8)	Equation (9)	(Equation 10)
STEM	-1.182 [0.237]**	-1.215 [0.248]**	-1.185 [0.237]**	-1.222 [0.248]**
Social Sciences	-0.905 [0.232]**	-0.943 [0.245]**	-0.909 [0.232]**	-0.950 [0.245]**
Humanities	-0.992 [0.275]**	-1.039 [0.295]**	-0.994 [0.274]**	-1.045 [0.293]**

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 20

Master's Degrees - STEM as Reference Category

	Equation (3)	Equation (8)	Equation (9)	(Equation 10)
Social Sciences	0.276 [0.147]+	0.272 [0.149]+	0.276 [0.148]+	0.271 [0.150]+
Humanities	0.189 [0.199]	0.175 [0.204]	0.191 [0.201]	0.177 [0.205]
Business Management	1.182 [0.237]**	1.215 [0.248]**	1.185 [0.237]**	1.222 [0.248]**

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 21

Master's Degrees - Social Sciences as Reference Category

	Equation (3)	Equation (8)	Equation (9)	(Equation 10)
Humanities	-0.087 [0.175]	-0.096 [0.176]	-0.084 [0.177]	-0.095 [0.178]
Business Management	0.905 [0.232]**	0.943 [0.245]**	0.909 [0.232]**	0.950 [0.245]**
STEM	-0.276 [0.147]+	-0.272 [0.149]+	-0.276 [0.148]+	-0.271 [0.150]+

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 22

Master's Degrees - Humanities as Reference Category

	Equation (3)	Equation (8)	Equation (9)	(Equation 10)
Business Management	0.992 [0.275]**	1.039 [0.295]**	0.994 [0.274]**	1.045 [0.293]**
STEM	-0.189 [0.199]	-0.175 [0.204]	-0.191 [0.201]	-0.177 [0.205]
Social Sciences	0.087 [0.175]	0.096 [0.176]	0.084 [0.177]	0.095 [0.178]

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 23

Doctoral Degrees - Business Management as Reference Category

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
STEM	0.520 [0.289]+	0.576 [0.309]+	0.574 [0.299]+	0.655 [0.329]*
Social Sciences	0.460 [0.283]	0.518 [0.301]+	0.519 [0.291]+	0.604 [0.320]+
Humanities	0.249 [0.315]	0.325 [0.331]	0.285 [0.325]	0.394 [0.350]

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 24

Doctoral Degrees - STEM as Reference Category

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
Social Sciences	-0.060 [0.128]	-0.058 [0.128]	-0.055 [0.120]	-0.051 [0.120]
Humanities	-0.272 [0.153]+	-0.251 [0.150]+	-0.289 [0.154]+	-0.261 [0.152]+
Business Management	-0.520 [0.289]+	-0.576 [0.309]+	-0.574 [0.299]+	-0.655 [0.329]*

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 25

Doctoral Degrees - Social Sciences as Reference Category

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
Humanities	-0.212	-0.193	-0.234	-0.210
	[0.157]	[0.155]	[0.145]	[0.143]
Business Management	-0.460	-0.518	-0.519	-0.604
	[0.283]	[0.301]+	[0.291]+	[0.320]+
STEM	0.060	0.058	0.055	0.051
	[0.128]	[0.128]	[0.120]	[0.120]

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 26

Doctoral Degrees - Humanities as Reference Category

	Equation (4)	Equation (11)	Equation (12)	Equation (13)
Business Management	-0.249 [0.315]	-0.325 [0.331]	-0.285 [0.325]	-0.394 [0.350]
STEM	0.272 [0.153]+	0.251 [0.150]+	0.289 [0.154]+	0.261 [0.152]+
Social Sciences	0.212 [0.157]	0.193 [0.155]	0.234 [0.145]	0.210 [0.143]

Robust (bootstrap) standard errors in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

CHAPTER 5

SUMMARY AND CONCLUSION

This chapter is divided into five sections. The first section summarizes the results concerning each of the research questions and hypotheses in this study. The second section discusses the different findings and draws conclusions that might better inform decision making and policy concerning the production of degrees. As such, the third section focusing on the conclusions offers some implications for policy. The subsequent section provides recommendations for future research, which are mainly related to data availability. The chapter ends with a final thought concerning some of the findings discussed in the policy implications and their connection to the statement of the problem mentioned in chapter one.

Summary

The findings related to research question one, indicated that size (total instructional FTE) had a significant and positive effect across all three degree types (i.e. bachelor's degrees, master's degrees, and doctoral degrees) while instructional type varied by degree. For bachelor's degrees and master's degrees, tenured/tenure track faculty produced more degrees than credit bearing teaching assistants; there were no statistically significant differences in degree production between the former and the other instructional types in the models. The opposite was the case for doctoral degree production where tenured/tenure track faculty consistently produced more degrees than all instructional types.

Concerning the financial variables (direct instructional expenditures and research expenditures per tenured/tenure track faculty), there were differences between baccalaureate and doctoral degree production and the production of master's degrees. That is, both financial variables had a significant and positive effect on the production of master's degrees while a lack of significance was found in direct instructional expenditures for bachelor's degrees and doctoral degrees. Research expenditures per tenured/tenure track faculty showed some evidence of significance for baccalaureate degree production while firm and consistent evidence of significance was observed for this variable on doctoral degree production.

In addition, the analysis found a statistically significant association between each of the dependent variables and some of the control variables. Organized class sections taught per tenured/tenure track faculty at the undergraduate level and graduate level respectively had a positive and significant effect across all three degree types. Class size showed its strongest effect for the production of master's degrees where the effect was consistently significant and positive. Class size showed some significance for bachelor's degrees (positive effect) and no significance for doctoral degrees.

The findings related to the second research question, indicated that size (total instructional FTE) had the greatest positive effect on degree production across all three degree types. The magnitude of subsequent factors varied by degree type and by equations within bachelor's degrees and doctoral degrees. Overall, size was followed by organized class sections taught per tenured/tenure track faculty at the undergraduate level for bachelor's degrees, class size at the graduate level for master's degrees, and STEM for doctoral degrees.

For the third research question, both the field of business management and social sciences produced more bachelor's degrees than STEM and humanities while no statistical significant differences in production were found between business management and social sciences and between humanities and STEM. For master's degrees, the findings provided strong evidence that the field of business management produced more degrees than the other fields. In addition, social sciences produced more master's degrees than STEM and no statistical significant differences in master's degree production were found between social sciences and humanities and between humanities and STEM. For doctoral degrees, the findings provided some evidence that STEM produced more doctoral degrees than humanities and business management with no statistical difference in doctoral degree production between STEM and social sciences. The latter, however, showed some evidence of producing more doctoral degrees than business management.

Findings from the analysis in chapter four provided support for hypothesis 1 across all three degree types in that all of the significant coefficients for the continuous variables were positive indicating an increasing marginal effect in degree production. Hence, the concept of production function provided explanatory power for degree production.

The findings did not support hypothesis 2 and offered partial support for hypothesis 3. For the former, no statistical significant differences in baccalaureate degree production were found among instructional type except for credit bearing teaching assistants, which was marginally significant at the 10% level and had a negative sign. The latter, going in the opposite direction of hypothesis 2, indicated that tenured/tenure track faculty actually produced more degrees than credit bearing teaching assistants.

Concerning hypothesis 3, the findings provided partial support in that similar to bachelor's degrees, only the percentage for credit bearing teaching assistants showed a statistical significant effect on master's degree production indicating that tenured/tenure track faculty produced more master's degrees than this particular instructional type. On the other hand, the opposite was the case for doctoral degree production where the findings showed that tenured/tenure track faculty consistently produced more doctoral degrees than all instructional types. Thus, utility maximization theory offered explanatory power for doctoral degree production, but partial support for the production of either bachelor's degrees or master's degrees.

Partial support was also found for hypotheses 4 and 5. More specifically, hypothesis 4 was fully supported concerning the production of master's degrees in that the findings consistently showed that business management, the field considered to be closer to the market as indicated in chapter four, produced more master's degrees than the other fields in the model. The latter, however, was not the case in regard to the production of bachelor's degrees where STEM and to a lower extent humanities showed some statistical significance in producing fewer degrees than business management. As in the case of hypothesis 4, the findings provided partial support for hypothesis 5 in that STEM, the field considered to be closer to the federal research market as previously indicated, showed marginal evidence of producing more doctoral degrees than business management and humanities with no statistical significant difference in production when compared to the field of social sciences. As such, academic capitalism offered explanatory power for the production of master's degrees and to a lower extent for baccalaureate and doctoral degree production.

The findings fully supported hypothesis 6 although the effect did not appear to be strong. Nonetheless, the variable representing research expenditures did have a statistical, significant, and positive effect on the production of doctoral degrees, which supported the aid of academic capitalism theory to explain the production of doctoral degrees.

Conclusions

Prior to discussing the findings and offering some conclusions, it is important to remind the reader that, as indicated in the limitations section, the sample analyzed in this study was limited to AAU public research universities. AAU universities represent a specific type of institutions with a specific mix of products and activities that focus more highly on research. For this reason, after discussing the findings, this section, speculatively, considers what these results might look like in non-AAU public research universities.

The findings in this study are overall consistent with the literature reviewed in chapter two in regard to the effect of size on instructional production and somewhat mixed concerning the effect of the financial variables on this same outcome. For the former, size (as measured by instructional FTE) was significant and positive across all three degree types in this study. A similar effect was found by Sengupta (1975), Olson (1994), Gander (1995, 1999), Ryan (2004), and Ehrenberg and Zhang (2005) in their respective analysis. Moreover, this study showed that instructional FTE had the greatest effect on degree production for all three types (bachelor's degrees, master's degrees, and doctoral degrees) when the coefficients were standardized. This finding is in line with the cost studies, which have indicated that instructional FTE is among the main inputs for production (de Groot et al.,1991; Dundar & Lewis, 1995; Lewis & Dundar, 2001).

On the other hand, the findings concerning the financial variables (i.e. direct instructional expenditures and research expenditures per tenured/tenure track faculty) are somewhat mixed when examining them against the literature. That is, as mentioned in chapter two, the degree production studies and some of the additional studies related to the research questions, found that financial resources had a significant and positive effect on instructional production (Bound & Turner, 2007; Breneman, 1970; Dolan & Schmidt, 1994; Ryan, 2004; Titus, 2009b; Zhang, 2009). Although the findings in this study showed that the financial variables had a similar effect on degree production, they are mixed in that a significant and positive effect was indeed found for both variables on the production of master's degrees while direct instructional expenditures had no effect on both bachelor's degrees and doctoral degrees. Research expenditures per tenured/tenure track faculty, on the other hand, had a marginal positive effect on bachelor's degrees and a strong significant and positive effect on doctoral degrees.

The lack of significance of direct instructional expenditures on both bachelor's degrees and doctoral degrees found in this study as compared to the literature can perhaps be explained by differences in the unit of analysis, the way this particular variable was measured, and the method employed. The studies in the literature that focused on either baccalaureate degree production or graduation rates conducted their analysis by using institutions rather than academic departments and measured financial resources by using state need-based aid financial aid (Titus, 2009b) and state appropriation (Bound and Turner, 2007; Titus, 2009a; Zhang, 2009). In addition, some of these studies employed panel data and used different methods of estimation. Conversely, as indicated in chapter three, financial resources in this study were measured by direct instructional expenditures and research expenditures per tenured/tenure track faculty per academic department by CIP. The former, in particular, was constructed by dividing academic departments' (by CIP) total instructional expenditures for the fiscal year by their total number of undergraduate and graduate student credit hours for the academic year. Hence, this variable is more representative of cost than revenue.

Examining production by degree type, for bachelor's degrees, it was interesting that except for credit bearing teaching assistants there were no statistically significant differences in production between tenured/tenure track faculty and the other instructional types in the model. At the same time, the variable representing organized class sections taught per tenured/tenure track faculty at the undergraduate level was consistently significant and positive. As such, these findings could indicate that an increase in baccalaureate degree production is not necessarily obtained by increasing the proportion of tenured/tenure track faculty, but rather by having tenured/tenure track faculty teach more undergraduate classes. However, increasing the teaching load for this instructional type might have a significant negative impact on research production, which was not captured in this study.

For master's degrees, given the popularity of the Master of Business Administration (MBA) degree and its closeness to the market, it was not surprising to see that the field of business management produced more master's degrees than all other fields. Another of the salient findings for master's degrees was that of class size. The coefficients for this variable had a significant and positive effect on the production of master's degrees. In fact, among standardized coefficients class size had the second strongest effect. It is interesting that among the three degree types (bachelor's degrees, master's degrees, and doctoral degrees) class size was consistently and strongly significant only for master's degrees. This significant effect of class size on the production of master's degrees, together with the additional significant coefficients, might point to efficiency in the production process for this particular type of degree. That is, when considering the input-output relation where master's degrees were produced by filling classrooms with large number of students where additional departmental factors were contributing towards its production.[12] This efficiency in production could be further supported by considering that, on average, it only takes two years to produce a master's degree; students are often professionals with available resources, hence, higher tuition can be charged; and no dissertation work is generally required to obtain the degree. In sum, the findings in this study

[12] All of the significant coefficients for this degree type had a positive sign indicating a positive effect and/or contribution towards the production of master's degrees.

may indicate that master's degree production embodies an efficient degree production industry, which could lead to revenue generation as explained by academic capitalism.

For doctoral degrees, the field of STEM, which had the second greatest effect on doctoral degree production, showed marginal evidence of producing more doctoral degrees than both humanities and business management while no statistical significance was observed when compared to social sciences. This marginal significance and lack of significance respectively can perhaps be attributed to the aggregation scheme employed in this study. More specific information could possibly be obtained by disaggregating the current fields into narrower areas of study. Nonetheless, there is a tradeoff between obtaining such information and the statistical price to pay for reducing the number of degrees of freedom by adding more variables to the model. Other than the marginal significance and lack of statistical significance between STEM and social sciences due to the aggregation scheme, as explained above, all of the three theories employed in this study (production function, utility maximization, and academic capitalism) showed explanatory power for the production of doctoral degrees.

In addition, it was interesting to observe the effect of research expenditures per tenured/tenure track faculty on doctoral degree production. The coefficients for this variable were significant and positive across all four equations; however, the magnitude was apparently small. Chapter four indicated that for every 10% increase in research expenditures per tenured/tenure track faculty, doctoral degree production increased by approximately .4 to .6 % net of all of the other variables in the model. An increase of .6% in doctoral degree production for every 10% increase in research expenditures per tenured/tenure track faculty, *ceteris paribus*,[13] does not seem that it would have a great practical impact on production. However, when considering the descriptive statistics for doctoral degrees one realizes the significance of

[13] All other (relevant) factors being equal or held constant

this coefficient. From the descriptive statistics, a .6 increase in doctoral degree production amounts, on average, to .048 degrees [14] for every 10% increase in research expenditures per tenured/tenure track faculty; research expenditures per tenured/tenure track faculty averaged $223,679; and total instructional FTE per CIP averaged 33 out of which approximate, and on average, 60% were tenured/tenure track faculty resulting in 20 tenured/tenure track faculty members. Using these values as a reference, one can estimate that, on average, if only 12 out of the 20 tenured/tenure track faculty members increased their research expenditures per year by 30% (i.e. an average of $66,000 per year per faculty member for contracts and grants), almost 2 doctoral degrees would have been produced, *ceteris paribus*. Not a small effect when one considers from the descriptive statistics that, on average, two degrees represented one fourth of the total doctoral degree production by academic departments during academic year 2005-2006.

Non-AAU Public Research Universities

As indicated in the beginning of this segment, the analysis in this study was limited to AAU public research universities. These are institutions whose mix of products and activities tend to be more research oriented. This orientation could perhaps explain the lack of significance observed overall for the instructional type variables when compared against tenured/tenure track faculty in the production of bachelor's degrees and master's degrees, as well as, the significance of research expenditures per tenured/tenure track faculty across all three degree types.[15] Hence, it is interesting to consider what these results might look like in non-AAU public research universities. As such, one can entertain the possibility that non-AAU public research universities

[14] Based on an average of 8 doctoral degrees per CIP per year.

[15] Only the percentage of credit bearing teaching assistants (% TA credit) was significant in both baccalaureate degree production (significance at the 10% level) and master's degree production (significance at the 1% level). The variable for research expenditures per tenured/tenure track faculty was significant (significance at the 10%) in two equations for bachelor's degrees and across all four equations for master's degrees (significance at the 10% level) and doctoral degrees (significance at the 1% level).

might show less of an emphasis concerning research expenditures per tenured/tenure track faculty on degree production and more of an emphasis on baccalaureate degree production by its tenured/tenure track faculty. However, given the lack of available departmental data on non-AAU public research universities for this study, one is limited to mere speculation. Due to this substantial limitation, I point the reader to the theory of organizational isomorphism (DiMaggio & Powell, 1983), which argues for the homogenization of organizations. Within the mechanisms through which institutional isomorphic change occurs, DiMaggio and Powell indicate that "organizations tend to model themselves after similar organizations in their field that they perceive to be more legitimate or successful" (p.152). Given that AAU public research universities tend to exert such characteristics (i.e. legitimacy and success), if one is to speculate, it would seem reasonable given the theory of organizational isomorphism, to think that non-AAU public research universities perhaps try to emulate AAU institutions and as such might show similar results as those reported here. This conjecture could gain further support when considering that non-AAU public research universities are not exempt to the influence of academic capitalism and utility maximization as explained in this study and the fact that although these institutions are not AAU members, they are still public research universities that share a similar mission (teaching, research, and service) to that of AAU members and whose emphasis is also research for they are after all research universities.

Policy Implications

Before drawing on the several implications for policy, it is important to be mindful of the potential two-way causation present in these data due to the possible interaction of supply and demand as explained in the limitations section. Given supply, this study assumes that total instructional FTE drives degree production and not the other way around. Hence, caution should be exercised when considering these implications.

Several policy implications can be derived from this study. First, the continuous, positive, and significant effect of size (total instructional FTE) on instructional production might point to the importance for university administrators and decision makers to support policies that would allow academic departments to grow given the magnitude of its impact on production (size had the greatest effect on degree production when examining standardized coefficients). University administrators and decision makers might want to keep this mind, especially during times of budget cuts in that it would perhaps be during these times that degree production could be hindered the most by the common hiring freezes, layoffs, furloughs, and additional decisions and/or practices that might reduce or even threaten reducing the academic department's size. Of course, when budget cuts are extreme, extreme measures are sometimes necessary; nonetheless, it is important that university administrators and decision makers be aware of the potential negative impact that reducing a department's size could have on degree production. Such impact can be devastating when considering the impending demand for highly skilled graduates in the current knowledge-intensive economy and the significance that degree production has for individuals, society, and the nation's well being overall.

Second, because this study used several controls for quality, it is advantageous and profitable for university administrators and decision makers to consider that, *ceteris paribus,* increasing class size mainly for master's degrees and to a certain extent for bachelor's degrees might not have a negative effect on production, but actually the opposite could be the case.[16]

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[16] Class size was positive, significant, and had the second strongest effect on the production of master's degrees across all four equations, each of which represented a different attempt to control for quality. This same variable was marginally significant in equation (2) for bachelor's degrees and significant at the 5% level on equation (6) for this same degree type.

Nonetheless, caution should be given to this finding in that quality is subjective and difficult to measure. Hence, although this study provides some evidence concerning the effect of class size after controlling for quality, further analysis should be considered with additional or more precise indicators of quality to confirm the significant and positive effect of class size, *ceteris paribus*, on the production of master's degrees and to a lower extent on bachelor's degrees after controlling for quality.

Lastly, university administrators and decision makers should consider the presence of a possible tradeoff between baccalaureate degree production and the production of research, as well as, between baccalaureate degree production and the production of doctoral degrees. This study found that increasing the production of bachelor's degrees was not dependent upon increasing the percentage of tenured/tenure track faculty, but rather on having tenured/tenure track faculty teach more undergraduate classes. However, given the time constraint of this instructional type, it is likely that having tenured/tenure track faculty teach more undergraduate classes could perhaps have a negative impact on both research production and the production of doctoral degrees due to the fact that these are areas where tenured/tenure track faculty tend to focus most of their time. This tradeoff is intensified by the significant positive effect that research expenditures per tenured/tenure track faculty had on doctoral degree production. Hence, caution should be given when considering this tradeoff, especially because the mission of public research universities includes both teaching and research where the former usually focuses on undergraduate instruction for accountability reasons at the state level.

Future Research

Several aspects should be considered for future research related to the topic of this study, all of which have to do with data availability. As such, increasing sample size and expanding it to non-AAU public research universities, as well as, obtaining panel data specific to degree program, which might disaggregate instructional expenditures in a more detailed manner are among the primary recommendations. As long as the sample is random, having the largest number of observations possible is always preferred in econometric analysis for the law of large numbers to take effect in estimation and to avoid issues dealing with not having enough degrees of freedom. For this reason, there is a tendency to pool observations across units and over time to increase sample size. However, when pooling over time, cross-sectional OLS and/or cross-sectional SUR are no longer justified in that either a time series or panel data analysis respectively are more appropriate for data collected over time on repeated observations. Nonetheless, if OLS or SUR are preferred, researchers can still conduct a cross-sectional analysis as long as they do not pool data on the same units over time; otherwise the sample would no longer be considered random due to correlated errors, which leads to biased estimation. Adding non-AAU data to the sample will also be helpful for generalization purposes. Moreover, having access to panel data is always preferred as compared to cross-sectional data considering that the former is able to account for time and for omitted variable bias, as long as, the unobservables are time-invariant. The issue of availability of data specific to degree program that might further disaggregate financial variables, as with the issue related to quality, is prevalent in higher education. It is extremely difficult to find detailed data on revenues and expenditures by instructional type (i.e. tenured/tenure track faculty, adjunct faculty, and graduate assistants), level (i.e. undergraduate and graduate), and activity (instruction, research, and service).

An additional aspect to consider encompasses the potential presence of a two-way causation given by the possibility of supply and demand interacting with each other as it relates to instructional FTE and instructional output. As such, future research could perhaps attempt to include additional variables that might work as a proxy or instrument to account for this potential two-way causation commonly known as endogeneity. If such variable or variables are available, the analysis could employ a combination of a two-stage least squares (2SLS) regression with seemingly unrelated regression.

Future analysis should also include the production of research as an additional outcome to be explored. Adding research production would capture variance left out by the production of instruction. In this same train of thought, exploring outcomes related to service would complement the analysis of academic departments given the multiproduct function of research universities. Nonetheless, service in current times can be related to research production via technology transfer products such as patents, research publications, and the like given the knowledge-intensive economy.

Furthermore, disaggregating fields of study into narrower areas and/or conducting analysis, similar to the one employed in this study, for each of these narrower areas would help obtain more specific information for each of the fields. However, such analysis would require a much larger sample for the reasons mentioned above. Not to mention, adding time to the data in order to have panel data, which as previously indicated is always preferred.

Finally, future research could benefit by considering additional or more precise indicators to control for quality. As already pointed out, this is always an issue in that quality is difficult to measure given its subjectivity and difference of opinion among different sectors. Nevertheless, researchers should not be restricted by this limitation. On the contrary, they should continue adding alternative measures to their models to obtain further knowledge concerning this variable through systematic research.

Final Thought

Taking into consideration the statement of the problem for this study, as indicated in chapter one, I would like to finish this work by focusing on the last point made under the policy implications section. This refers to the finding concerning a possible tradeoff between baccalaureate degree production and the production of doctoral degrees, as well as, between baccalaureate degree production and the production of research. This tradeoff was highlighted based on the potential factors needed, according to the findings in this study, to increase the production of bachelor's degrees (mainly having tenured/tenure track faculty teach more undergraduate classes) and the effect of research expenditures on doctoral degree production. It was indicated that having tenured/tenure track faculty teach more undergraduate classes could, in turn, lead to a potential negative effect on doctoral degree and research production given the time constraint of this instructional type. As such, it was suggested that university administrators and decision makers might need to be aware and cautious concerning such tradeoff.

This tradeoff could be further exacerbated when one considers both the mission of public research universities in the United States (teaching, research, and service) and the nation's goal for degree production established by President Barack Obama for the year 2020. The former tends to focus on undergraduate instruction for accountability reasons at the state level, but also on research production in that these are after all research universities. In turn, research is usually linked to graduate work, mainly doctoral degrees; hence, the conflict when considering the aforementioned potential tradeoff. Obama's 2020 goal, on the other hand, was set due to the impending demand for highly skilled workers as a result of the knowledge-intensive economy, which translates mainly into baccalaureate degree production. However, Obama's 2020 goal implies economic development and global competitiveness, which is also tied to research and as such to graduate work (doctoral degrees). Therefore, producing baccalaureate degrees together with research production, which is linked to doctoral degree production, is emphasized yet the potential tradeoff between baccalaureate degree production and the production of doctoral degrees, as well as, between baccalaureate degree production and the production of research is not mentioned in policy discussions. Hence, policy and decision makers at the federal and state levels together with university administrators might want to be cognizant of this tradeoff and should perhaps decide the course of public research universities for the next ten years in regard to degree production, as well as, research production (in that doctoral degrees are tied to research, which in turn, is tied to economic development via innovation). How are government and university officials handling this potential tradeoff as it relates to policy? Do federal, state, and university policies conflict with each other given the aforementioned tradeoff? Questions similar to these need to be part of such discussion, especially because due to this tradeoff, unless agreement and a central focus braids these policies, the U.S. might not be able to meet its degree production goal in the year 2020 and more important meet the impending demand for skilled workers imposed by the knowledge-intensive economy.

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APPENDICES

Appendix A

Academic Departments Coded as Service Field

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
05.02	Ethnic, Cultural Minority, and Gender Studies
09.01	Communication and Media Studies
11.01	Computer and Information Sciences, General
11.07	Computer Science.
16.01	Linguistic, Comparative, and Related Language Studies and Services
16.05	Germanic Languages, Literatures, and Linguistics
16.09	Romance Languages, Literatures, and Linguistics
16.12	Classics and Classical Languages, Literatures, and Linguistics
23.01	English Language and Literature, General.
24.01	Liberal Arts and Sciences, General Studies and Humanities
26.01	Biology, General.
26.03	Botany/Plant Biology.
26.07	Zoology/Animal Biology.
26.09	Physiology, Pathology and Related Sciences
26.13	Ecology, Evolution, Systematics, and Population Biology
27.01	Mathematics
27.05	Statistics
38.01	Philosophy
38.02	Religion/Religious Studies
40.02	Astronomy and Astrophysics
40.05	Chemistry
40.06	Geological and Earth Sciences/Geosciences
40.08	Physics
42.01	Psychology, General
45.02	Anthropology
45.06	Economics
45.07	Geography and Cartography
45.10	Political Science and Government, General.

Appendix A

(Continued)

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
45.11	Sociology
50.03	Dance
50.05	Drama/Theatre Arts and Stagecraft
50.06	Film/Video and Photographic Arts
50.07	Fine and Studio Art
50.09	Music
54.01	History

Appendix B

Academic Departments Coded as STEM

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
01.09	Animal Sciences
01.10	Food Science and Technology
01.11	Plant Sciences
01.12	Soil Sciences
03.01	Natural Resources Conservation and Research
03.05	Forestry
03.06	Wildlife and Wildlands Science and Management
03.99	Natural Resources and Conservation, Other
04.02	Architecture
04.06	Landscape Architecture
11.01	Computer and Information Sciences, General
11.07	Computer Science.
14.01	Engineering, General
14.02	Aerospace, Aeronautical and Astronautical Engineering
14.03	Agricultural/Biological Engineering and Bioengineering
14.05	Biomedical/Medical Engineering
14.07	Chemical Engineering
14.08	Civil Engineering
14.10	Electrical, Electronics and Communications Engineering
14.12	Engineering Physics
14.18	Materials Engineering
14.19	Mechanical Engineering
14.21	Mining and Mineral Engineering
14.27	Systems Engineering
14.31	Materials Science
14.35	Industrial Engineering
26.01	Biology, General.
26.02	Biochemistry, Biophysics and Molecular Biology
26.03	Botany/Plant Biology.
26.04	Cell/Cellular Biology and Anatomical Sciences
26.05	Microbiological Sciences and Immunology
26.07	Zoology/Animal Biology.
26.08	Genetics

Appendix B

(Continued)

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
26.09	Physiology, Pathology and Related Sciences
26.10	Pharmacology and Toxicology
26.13	Ecology, Evolution, Systematics, and Population Biology
27.01	Mathematics
27.03	Applied Mathematics
27.05	Statistics
30.19	Nutrition Sciences
40.02	Astronomy and Astrophysics
40.04	Atmospheric Sciences and Meteorology
40.05	Chemistry
40.06	Geological and Earth Sciences/Geosciences
40.08	Physics
45.07	Geography and Cartography
51.02	Communication Disorders Sciences and Services
51.07	Health and Medical Administrative Services
51.16	Nursing
51.20	Pharmacy, Pharmaceutical Sciences, and Administration
51.22	Public Health

Appendix C

Academic Departments Coded as Social Sciences

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
01.01	Agricultural Business and Management
04.03	City/Urban, Community and Regional Planning
05.01	Area Studies
05.02	Ethnic, Cultural Minority, and Gender Studies
09.01	Communication and Media Studies
09.04	Journalism
09.07	Radio, Television, and Digital Communication
13.01	Education, General
13.02	Bilingual, Multilingual, and Multicultural Education
13.03	Curriculum and Instruction
13.04	Educational Administration and Supervision
13.09	Social and Philosophical Foundations of Education
13.10	Special Education and Teaching
13.11	Student Counseling and Personnel Services
13.13	Agricultural Teacher Education
16.01	Linguistic, Comparative, and Related Language Studies and Services
25.01	Library Science/Librarianship
30.20	International/Global Studies
42.01	Psychology, General
42.06	Counseling Psychology
42.18	Educational Psychology
44.04	Public Administration
44.05	Public Policy Analysis
45.02	Anthropology
45.06	Economics
45.10	Political Science and Government
45.11	Sociology

Appendix D

Academic Departments Coded as Humanities

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
16.02	African Languages, Literatures, and Linguistics
16.03	East Asian Languages, Literatures, and Linguistics
16.04	Slavic, Baltic and Albanian Languages, Literatures, and Linguistics
16.05	Germanic Languages, Literatures, and Linguistics
16.07	South Asian Languages, Literatures, and Linguistics
16.09	Romance Languages, Literatures, and Linguistics
16.11	Middle/Near Eastern and Semitic Languages, Literatures, and Linguistics
16.12	Classics and Classical Languages, Literatures, and Linguistics
23.01	English Language and Literature, General
23.05	Creative Writing
24.01	Liberal Arts and Sciences, General Studies and Humanities
38.01	Philosophy
38.02	Religion/Religious Studies
50.03	Dance
50.05	Drama/Theatre Arts and Stagecraft
50.06	Film/Video and Photographic Arts
50.07	Fine and Studio Art
50.09	Music
54.01	History

Appendix E

Academic Departments Coded as Business Management

CIP - 4 DIGIT LEVEL	NCES LABEL AT THE 4 DIGIT CIP LEVEL
52.01	Business/Commerce, General
52.02	Business Administration, Management and Operations
52.03	Accounting and Related Services
52.08	Finance and Financial Management Services
52.12	Management Information Systems and Services
52.14	Marketing
52.15	Real Estate
52.17	Insurance

Appendix F

Summary Table of Equations (2) through (13)

	Bachelor's Degrees				Master's Degrees				Doctoral Degrees			
Variables	Equations				Equations				Equations			
	(2)	(5)	(6)	(7)	(3)	(8)	(9)	(10)	(4)	(11)	(12)	(13)
% Non-tenure track	x	x	x	x	x	x	x	x	x	x	x	x
% Part-time	x	x	x	x	x	x	x	x	x	x	x	x
% TA credit	x	x	x	x	x	x	x	x	x	x	x	x
% TA non-credit	x	x	x	x	x	x	x	x	x	x	x	x
Tot. instruct. FTE (log)	x	x	x	x	x	x	x	x	x	x	x	x
Direct instruct. exp. (log)	x	x	x	x	x	x	x	x	x	x	x	x
Research exp. (log)	x	x	x	x	x	x	x	x	x	x	x	x
Org. class TTT_UND (log	x	x	x	x								
Org. sec. TTT_ GRAD (log)					x	x	x	x	x	x	x	x
Class size UND (log)	x	x	x	x								
Class size GRAD (log)					x	x	x	x	x	x	x	x
Service field	x	x	x	x								
STEM	x	x	x	x	x	x	x	x	x	x	x	x
Social Sciences	x	x	x	x	x	x	x	x	x	x	x	x
Humanities	x	x	x	x	x	x	x	x	x	x	x	x
Proxy for qual. (log)		x		x		x		x		x		x
Inst. qual. score (log)			x	x			x	x			x	x

Notes:

1) x indicates that the variable on the left is included in the equation above.

2) In all of the equations, % Tenured/tenure track & Business Management are omitted to constitute reference categories respectively.

Appendix G

SUR Estimation of Equations (2) through (13)

	1st. SUR Estimation			2nd. SUR Estimation			3rd. SUR Estimation			4th. SUR Estimation		
Variables	Equations			Equations			Equations			Equations		
	(2)	(3)	(4)	(5)	(8)	(11)	(6)	(9)	(12)	(7)	(10)	(13)
% Non-tenure track	x	x	x	x	x	x	x	x	x	x	x	x
% Part-time	x	x	x	x	x	x	x	x	x	x	x	x
% TA credit	x	x	x	x	x	x	x	x	x	x	x	x
% TA non-credit	x	x	x	x	x	x	x	x	x	x	x	x
Tot. instruct. FTE (log)	x	x	x	x	x	x	x	x	x	x	x	x
Direct instruct. exp. (log)	x	x	x	x	x	x	x	x	x	x	x	x
Research exp. (log)	x	x	x	x	x	x	x	x	x	x	x	x
Org. class TTT_UND (log	x			x			x			x		
Org. sec. TTT_ GRAD (log)		x	x		x	x		x	x		x	x
Class size UND (log)	x			x			x			x		
Class size GRAD (log)		x	x		x	x		x	x		x	x
Service field	x			x			x			x		
STEM	x	x	x	x	x	x	x	x	x	x	x	x
Social Sciences	x	x	x	x	x	x	x	x	x	x	x	x
Humanities	x	x	x	x	x	x	x	x	x	x	x	x
Proxy for qual. (log)				x	x	x				x	x	x
Inst. qual. score (log)							x	x	x	x	x	x

Note:
Equations in this study were estimated via the SUR method according to the groupings shown above; however, the results of this estimation are reported in the respective tables in chapter four by degree type.