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Estimating the Efficiency of Four-year Public Master's Universities in Arkansas Using Data Envelopment Analysis

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A dissertation submitted in partial fulfillment
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by

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ABSTRACT

For the fourth time in the past 20 years, the state of Arkansas has implemented a performance-funding program. Although directly referenced in the title of Act 1203 of 2011, the implemented performance-funding program does not include a measure of how efficiently institutions are converting their inputs into outputs. The purpose of this study was two-fold: (1) to examine, through the conceptual framework of agency theory, why the state of Arkansas adopted performance funding policy after experiencing three adopt-implement-abandon cycles in the past 20 years, and (2) to estimate the efficiency of four-year public Master's universities in Arkansas in achieving one of the mandatory measures in the performance-funding program: number of bachelor's degrees awarded. The institutions included in this study were Arkansas State University, Arkansas Tech University, and University of Central Arkansas in the larger group, and Henderson State University, Southern Arkansas University, and University of Arkansas at Monticello in the medium/smaller group. The analytical technique utilized in this study was based on Simar and Wilson's (2007) double bootstrap truncated regression approach. This study found that the six Arkansas institutions were inefficient in the production of bachelor's degrees during the 2011-2012 academic year, given the inputs included in the model and in relationship to the national sample of Master's Colleges and Universities. Through the second-stage regression analysis, this study also found that a state's per capita real gross domestic product (GDP) was a positive and statistically significant determinant of estimated efficiency for both groups of institutions (larger and medium/smaller). For the medium/smaller group, higher education's share of total state expenditures was a negative and statistically significant determinant of estimated efficiency, while the share of operating revenues based on net tuition was a positive and statistically significant determinant of estimated efficiency for the

larger group institutions. The existence of a performance-funding program was found to not be a significant determinant of institutional efficiency through the second-stage regression analysis. Using Eisenhardt's (1989) taxonomy of behavior- versus outcome-based contracts, this study also found that agency theory served as a viable conceptualization of why the state of Arkansas chose to adopt performance-funding policy for the fourth time since its initial adoption in 1995.

ACKNOWLEDGEMENTS

When asked by my third-grade teacher what I wanted to be when I grew up, I whole-heartedly responded: the quarterback of the Dallas Cowboys! In her wisdom of teaching school-aged children, she quickly offered a follow-up question akin to, "If THAT doesn't happen, what will you be?" Without hesitation, I stated that I wanted to be a professor. While not understanding the concept at the ripe old age of 8, that moment created in me an aspiration that has led to the completion of my doctoral studies at the University of Arkansas.

It is with great pleasure that I extend my thanks and gratitude to those who have had an especially significant influence and impact on my life during the process of achieving the long-held goal of earning a Ph.D. The completion of this dissertation certainly would not have happened without the advice, structure and support provided by my dissertation advisor, Dr. Michael Miller. Dr. Miller has been a constant source of knowledge and guidance throughout the past five years of my doctoral program, willing to entertain the seemingly random thoughts and concerns from an oft-times paranoid grad student. For this I will always be grateful. I greatly appreciate Dr. Valerie Hunt and Dr. Ketevan Mamiseishvili, who have served as tremendous supporters throughout my coursework and dissertation, offering timely and substantive feedback that has challenged me to think more deeply while considering diverse perspectives. Thank you to Dr. Wen-Juo Lo for engaging with me in the art and science of educational statistics while also demonstrating compassion during a difficult season of life. Thank you to Dr. Hong Son Nghiem for your willingness to share R code and respond expeditiously to my numerous requests for clarification regarding methodology.

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I would be remiss if I did not acknowledge my parents, Danny and Marta, for their support. In attendance at every athletic and co-curricular event in which I participated growing up, my parents continued to be a wonderful source of encouragement throughout my doctoral studies. Thank you for your willingness to spend hours on the phone during my hour-long drives home, listening intently as I recapped the latest policy theory or statistical technique learned during class, or yet another potential topic for a thesis. I especially have appreciated your enthusiasm and excitement during the writing and completion of this dissertation, which has provided me with an additional boost of encouragement when I needed it the most. I love you both very much!

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DEDICATION

This dissertation is dedicated to the greatest support system any doctoral student could have…to Jenny, to Evyn, to Elijah.

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CHAPTER I

INTRODUCTION

The realities of performance-based funding in Arkansas became more palpable with this headline in the Arkansas Democrat-Gazette: "2 Colleges Face Funding Cuts Under Formula" (April 26, 2014, Retrieved from http://www.arkansasonline.com). The two institutions, the University of Central Arkansas, a four-year university in Conway, and Southern Arkansas University Tech, a two-year community college in Camden, failed to earn the minimum six out of 10 points needed to obtain the 5% of base funding tied to performance measures outlined in the newly implemented performance-funding model for FY 2014. According to the article, extenuating circumstances may lead to the reinstatement of the funding losses to these two institutions. However, the recognition that failing to meet outcome thresholds established by the existing performance-funding model can result in funding losses is likely to serve as a reality check for stakeholders in higher education, as the state of Arkansas continues implementation of a program that will ultimately result in 25% of base funding being tied to performance measures in FY 2018 (ADHE, 2011).

Context of the Problem

Created by the adoption of Act 1203 of 2011, the newest iteration of performance-based funding in Arkansas is indicative of the shift toward greater external accountability that has been experienced in American higher education during the past 30 years. In 1985, the First National Conference on Assessment in Higher Education brought to the forefront a heightened focus on assessment, although issues such as definitions, instruments, and implementation that plagued the assessment movement of the 1980s remain concerns today (Ewell, 2002). More than 20 years later, the landmark report, A Test of Leadership: Charting the Future of U.S. Education, more

commonly known as the Spellings' Commission Report, indicated that calls for increased accountability require a systemic and systematic response: "To meet the challenges of the 21st century, higher education must change from a system primarily based on reputation to one based on performance. We urge the creation of a robust culture of accountability and transparency throughout higher education" (p. 21). A key recommendation stemming from the Spelling's Commission Report was shifting from a primary reliance on input-based measures of quality to a performance-based system in which outcomes are central to substantiate claims of institutional efficacy.

The trend for increasing higher education accountability has partially been attributed to policymakers recognizing that reporting requirements alone are insufficient mechanisms to improve operational efficiency, which has encouraged a "refocusing of attention, particularly in resource allocation, on outcomes of activities or programs, ideally in relation to explicit goals, rather than the traditional focus on inputs" (Zumeta, 2001, p. 16). The scrutiny by policymakers, characterized as the "crosshairs of legislative oversight" (Doyle & Noland, 2006, p. 7), is viewed by many policy researchers as justifiable, given that public policy and accountability are inextricably linked through the amount of public funds being provided to institutions of higher education from the state coffers (Zumeta, 2011). Heller (2011) stated that institutions of higher education have been scrutinized at increasing levels in recent years as more "attention has focused not only on what colleges and universities do, but also on how well they do it and what resources they use" (p. 2).

Policymakers are not the only stakeholders calling for increased accountability of American colleges and universities. Many employers have witnessed first-hand a misalignment of the skills college graduates exhibit on the job and the grades on college transcripts that

purportedly assure the development of educational capital needed when entering the workforce (Middaugh, 2010; Miller & Ewell, 2005; Miller, 2002). Parents preparing to fund their child's post-secondary education are faced with the challenge of paying for tuition, room and board at four-year public universities that has increased more than 40% between 2001-02 ($11,744 in constant 2011-12 dollars) and 2011-12 ($16,789 in constant 2011-12 dollars) (NCES, 2013a).

Various reasons have been posited for the perspectival shifts that have led to an increase in the view that higher education should be held more accountable. One such reason is the demise of an unwritten social compact between higher education and society. According to Burke (2005a), "Americans accepted as an unquestioned act of faith that access to a college education was a public good for society," as this social compact "obligated state taxpayers to provide adequate operating funding for public colleges and universities, which in turn would keep tuition reasonably low" (p. 5). Closely aligned with the relatively recent demise of the social compact is the perception that a college education provides more of a private benefit to the individual as opposed to benefiting society as a whole, even while colleges and universities are expected to contribute to the economic development of the state by producing well-trained citizens for the workforce (Burke & Associates, 2005; Wall, Frost, Smith, & Keeling, 2008). Based on the results of a series of national surveys, many Americans think that higher education is more necessary, yet less accessible to many qualified students; that institutions could increase the number of students educated while neither lowering the quality of education provided nor increasing costs for attendance; and that colleges and universities have become more corporate in nature, caring more about "the bottom line" as opposed to "making sure students have a good educational experience" (Immerwahr, Johnson, Ott, & Rochkind, 2010, p. 12). Given the existing economic climate in American states, policymakers have also increasingly begun to charge

higher education as deficient in its production of degreed and credentialed citizens who contribute to the economy.

The consistent calls for increased external accountability are in stark contrast to the level of autonomy that higher education, in general, has been afforded throughout much of its history. Autonomy in colleges and universities stems, in part, from the level of professionalism and education that characterizes institutions of higher education (Burke, 2005a). Colleges and universities also serve a unique "dual" role in society, as institutions are "both involved and withdrawn; both serving and criticizing; both needing and being needed" by those constituencies who provide support (Berdahl, 1990, p. 169). Thus, a clash between institutional autonomy and public accountability has resulted, in which, "Institutions of higher education face conflicting pressures both to protect their independence and autonomy (on grounds of greater effectiveness and lower cost), and simultaneously to demonstrate their accountability (on grounds of acting in the public interest)" (Volkwein & Tandberg, 2008, p. 181). Zumeta (2011) argued that a lack of response by higher education to external accountability efforts will likely result in institutions losing "stock with citizens and legislators" while "jeopardizing its support and ultimately its autonomy" (p. 142).

Within a climate where this autonomy-accountability tension is rising, an examination of productivity and quality indicators tends to support concerns expressed by various groups regarding the need for increased levels of accountability of colleges and universities. Policymakers linking educational attainment with economic viability can point to findings that indicate four-year college graduates annually contribute, on average, $5,900 more than high school graduates to local, state, and federal tax revenue, which translates to more than $177,000 additional tax dollars generated over a lifetime (USDOE, 2011a). Economic contribution extends

beyond tax revenue, as policymakers argue remaining competitive in a global marketplace will require substantial increases in the number of adults with post-secondary credentials. According to the Organisation for Economic Co-operation and Development (OECD, 2013), the United States ranks 5th in the world in the percentage (42% in 2011) of 25-64 year-old adults that have attained "tertiary education", but ranks only 12th in the percentage (43% in 2011) of 25-34 year-olds in this same category. The 25-34 year-old demographic is 21 percentage points behind the leading country, Korea, who has a 64% tertiary attainment rate for 25-34 year-old citizens (OECD, 2013). In recognition of these issues, President Obama, during his State of the Union Address in 2009, established a goal of having the "highest proportion of college graduates in the world" by 2020 (USDOE, 2011b). In order for this goal to be accomplished, it is estimated that the U.S. needs to raise the attainment rate by 50% from the 2009 level of 39%, which would bring the national college attainment rate to 60% in 2020 (USDOE, 2011b).

At the state level, Arkansas Governor Beebe utilized a similar platform in his State of the State Address in 2011, in which Beebe charged, "We can and must double the number of college graduates in Arkansas by 2025 if we are to stay competitive. This is a lofty goal aimed at the future, but we must begin implementing it today" (ADHE, 2011, p. 2). According to the U.S. Census Bureau's 2011 American Community Survey results, Arkansas ranked 48th in the country in the percentage of 25 to 64 year-old adults with a bachelor's degree or higher at 21.6%, and ranked 47th with 22.7% of 25 to 34 year-old adults with a bachelor's degree or higher (NCHEMS, Retrieved from http://www.higheredinfo.org/). For Arkansas to achieve Beebe's established goal, Arkansas institutions of higher education would need to increase the number of post-secondary credentials (bachelor's degrees, associate degrees, and certificates) awarded annually from 17,200 in 2011 to 34,400 in 2025 (NCHEMS, 2011).

The recognition that the state lacks an educationally-trained, competitive workforce, coupled with Beebe's charge in 2011, provided the political impetus for policymakers to revisit performance-funding policy. These efforts resulted in the passage of Act 1203 of 2011 that Beebe signed into law on April 5, 2011, and which led to the creation of the performance-funding model that currently exists in Arkansas (ADHE, 2011). The adoption of Act 1203 served as a continuation of Arkansas's history of performance-funding that has been characterized as a "classic case of volatility" (Burke & Associates, 2005, p. 224).

Burke (2002) provided the most extensive overview of performance-funding policy in Arkansas. The creation of the Productivity Fund through Act 1029 signed by Governor Jim Guy Tucker in April 1995 represented an endorsement of performance funding as a Not Mandated Program similar to those in place in Missouri and Tennessee. The Productivity Fund for the 1995-1997 biennium included $10 million in 1996-1997 and $15 million in 1997-1998 for performance-based funding. The first disbursement of these funds occurred during FY 1995-1996, with 70 percent of funds given to universities, 25 percent to two-year colleges, and five percent allocated for alumni/employer survey development. By 1997, the initial performance-funding system in Arkansas was terminated, as the demise of this performance funding effort was an amalgamation of loss of political support following the Whitewater scandal-based ousting of Tucker and the new priorities under his successor, Mike Huckabee; legislative and institutional push-back against the Department of Higher Education; and "Inherent flaws in the productivity program" collectively contributed to the failure of performance funding (Burke, 2002, p. 225). The second iteration of performance funding in Arkansas occurred with the passage of legislation mandating a new funding program in 2001, which was promptly abandoned in 2002 (Burke & Associates, 2005).

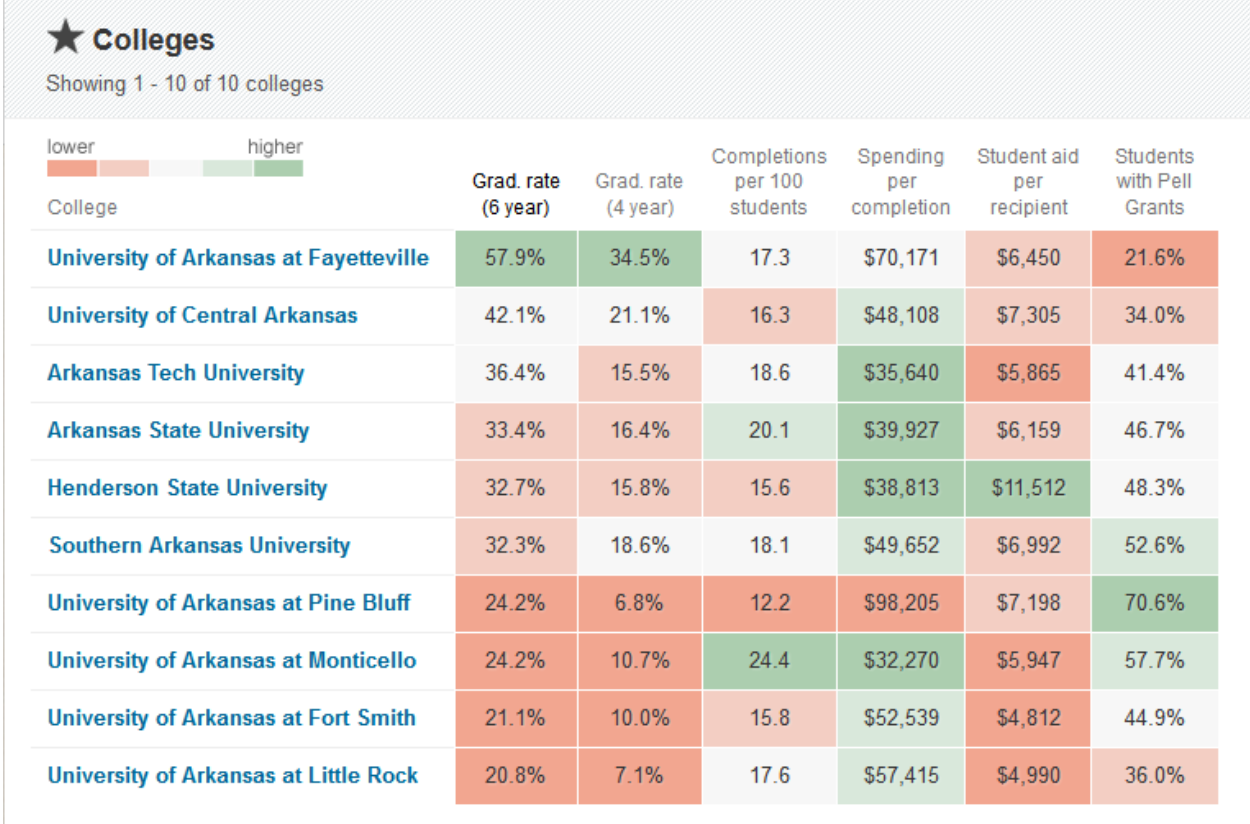
The current iteration of performance funding in Arkansas is an example of what has been deemed Performance Funding 2.0 (PF 2.0). For the first 25 years of performance-based funding in the United States, Performance Funding 1.0 (PF 1.0) programs focused primarily on providing bonuses, above and beyond state-level base funding, to institutions meeting student outcome measures (Dougherty & Reddy, 2013). Beginning in 2005, a number of states started adopting policies aligned with PF 2.0 principles, as these new programs shift the structure of incentives to reside within base funding formulas that require institutions to meet student outcome indicators in order to receive a portion of base funding (Jones & Snyder, 2012).

Another distinguishing feature of PF 2.0 programs is that a larger proportion of incentivized funding is linked to performance outcomes. Under PF 1.0 models, institutions would receive between 1% and 6% of a bonus for achieving certain outcomes, whereas PF 2.0 programs attach a significantly higher percentage of base funding to identified outcomes (Dougherty et al., 2014; Shin, 2010). For example, Tennessee's performance-funding program links 85-90% of state appropriations to performance outcomes, and Ohio has linked 80% of state general funding to measures of course and degree completions (Dougherty et al., 2014). In Arkansas, 25% of base funding will be tied to performance indicators once the program is fully implemented in 2017-18 (ADHE, 2011). At present, 25 states have already implemented, and five more states are transitioning to, funding models that incorporate student-level outcomes (PF 2.0) (NCSL, Retrieved from http://www.ncsl.org/).

Within performance-funding models, graduation rates serve as the primary metric by which institutional productivity is measured, as graduation rates serve as one of the primary areas of concern for proponents of PF 2.0 programs (Burke, 2005b; Rabovsky, 2012). In contrast to college-going rates that have increased nationally from 51% in 1975 to 68% in 2011(NCES,

2013b), six-year graduation rates, defined as a calculation of the full-time, first-time undergraduate students completing a bachelor's degree at their originating institution within six years, have increased from 52.2% for the 1991 cohort (NCHEMS, Retrieved from http://www.higheredinfo.org/) to 59.2% for all four-year institutions for the 2006 cohort (NCES, 2013b). In Arkansas public four-year institutions, the six-year graduation rate for the 1996 cohort was 35.4% and increased to 38.7% for the 2004 cohort, with a high of 40.4% for the 2001 cohort (Retrieved from http://collegecompletion.chronicle.com/).

The Chronicle of Higher Education's College Completion Web site also provides an institution-level view of how four-year public institutions compare to one another across a variety of measures. As can be seen in Figure 1, the 10 four-year public universities in Arkansas exhibit dramatically different results. Six-year graduation rates in 2010 ranged from 20.8% at the University of Arkansas at Little Rock to 57.9% at the University of Arkansas at Fayetteville. The measures of efficiency included in the College Completion chart, "Completions per 100 students" and "Spending per completion", indicate that the University of Arkansas at Monticello demonstrated the highest average number of completions per 100 students from 2008-2010 at 24.4, and spends the smallest amount per completion at $32,370. In contrast, the University of Arkansas at Pine Bluff had 12.2 completions per 100 students at a cost of $98,205 per completion.



★ Colleges

Showing 1 - 10 of 10 colleges

College	Grad. rate (6 year)	Grad. rate (4 year)	Completions per 100 students	Spending per completion	Student aid per recipient	Students with Pell Grants
University of Arkansas at Fayetteville	57.9%	34.5%	17.3	$70,171	$6,450	21.6%
University of Central Arkansas	42.1%	21.1%	16.3	$48,108	$7,305	34.0%
Arkansas Tech University	36.4%	15.5%	18.6	$35,640	$5,865	41.4%
Arkansas State University	33.4%	16.4%	20.1	$39,927	$6,159	46.7%
Henderson State University	32.7%	15.8%	15.6	$38,813	$11,512	48.3%
Southern Arkansas University	32.3%	18.6%	18.1	$49,652	$6,992	52.6%
University of Arkansas at Pine Bluff	24.2%	6.8%	12.2	$98,205	$7,198	70.6%
University of Arkansas at Monticello	24.2%	10.7%	24.4	$32,270	$5,947	57.7%
University of Arkansas at Fort Smith	21.1%	10.0%	15.8	$52,539	$4,812	44.9%
University of Arkansas at Little Rock	20.8%	7.1%	17.6	$57,415	$4,990	36.0%

Figure 1. Comparison of Arkansas Public Four-year Institutions. Adapted from *http://collegecompletion.chronicle.com/*.

The heightened cries for greater productivity from colleges and universities are occurring at the same time that funding from state and local governments has been proportionally decreasing, resulting in essentially a do-more-with-less scenario. In terms of raw dollars, state and local governments have increased direct support to institutions of higher education, as appropriations rose from $35.3 billion in 1985 ($74.8 billion in constant 2013 dollars) to $88.9 billion in 2008 before receding to $81.6 billion in 2013 (SHEEO, 2011, 2014). In terms of proportion, even with these increases, state and local support has been shrinking in the appropriations per FTE (full-time equivalent). In 1988, educational appropriations from state and local governments accounted for $8,579 per FTE (constant dollars), rising to a peak of $8,790 per FTE (constant dollars) in 2001, while this number dropped to $6,105 per FTE in 2013

(constant dollars) (SHEEO, 2014). During this period, net tuition revenue per FTE (constant dollars) increased by 103.9%, rising from $2,685 per FTE in 1988 to $5,475 per FTE in 2013 (SHEEO, 2014). In 1988, net tuition revenue per FTE accounted for 23.8% of the $11,264 (constant dollars) average cost per FTE of enrollment in public four-year institutions (SHEEO, 2014). In 2013, net tuition revenue per FTE accounted for 47.5% of the $11,580 (constant dollars) average cost per FTE of enrollment in public four-year institutions (SHEEO, 2014). These changes in per FTE funding indicate that a greater burden for financing higher education is being placed on students and their parents, supporting concerns from various stakeholders that decreasing the affordability of higher education will reduce access that will hinder the capacity of American universities to reach the goals set forth by state and federal policymakers. The current reality provided by the national- and state-level trends revealed by the performance and financial data lend credence to the observation that public institutions have become "instruments of public policy and strategic investment" that are now "too important and too costly to be left to (their) own devices" (Volkwein & Tandberg, 2008, p. 181).

Purpose of the Study

The purpose of this study was two-fold:

1. To utilize agency theory as a conceptual framework to explore the contractual relationship between the state of Arkansas and its public institutions of higher education created by the latest iteration of performance-funding policy; and,
2. To examine the institutional efficiency of the four-year public Master's universities in Arkansas toward achieving one of the mandatory outcomes, number of bachelor's degrees awarded, specified in the state's performance-funding program.

Performance-funding polices, which are essentially designed to increase institutional productivity through financial inducements (Burke, 2002; Conner & Rabovsky, 2011; Dougherty, Natow, Hare, Jones, & Vega, 2011), can be viewed as a contract between state governments and institutions (Kivistö, 2008). With its focus on the relationship between principal and agent, agency theory is well-suited to examine the motivations of both the government (principal) and institutions of higher education (agents) as it relates to achieving the goals and objectives desired by the principal (Eisenhardt, 1989; Jensen & Meckling, 1976; Moe, 1984).

With regard to the second purpose of this study, the legislation establishing the new performance-funding framework directly stipulates it was designed to "...ensure accountability and efficiency with our limited financial resources in trying economic times" (Arkansas Performance Funding Act of 2011, p. 7). However, the supporting documentation published by the Arkansas Department of Higher Education does not include any specific mechanism within the performance-funding model that accounts for the efficiency component of the legislation (ADHE, 2011). Therefore, this research applied an analytical methodology, data envelopment analysis (DEA), which has the potential to provide a component to Arkansas' performance-funding program that is currently missing: an evaluation of institutional efficiency.

Statement of Research Questions

In order to achieve the stated purpose, the following research questions were posited:

1. When compared to similar institutions nationally, how efficient are four-year public Master's universities in Arkansas at utilizing resources to achieve one of the mandatory measures (bachelor's degrees awarded) required by the new performance-funding program?

2. Which environmental factors contribute to the estimated efficiency of the inefficient four-year public Master's Colleges and Universities included in this study?
3. Does the existence of a performance-funding program impact the estimated institutional efficiency of the four-year public Master's Colleges and Universities included in this study?
4. What are the policy implications related to institutional efficiency within Arkansas' performance-funding program?

Definitions

The definitions below are associated with agency theory, which served as the conceptual framework of this study, and data envelopment analysis, which was the analytical technique used in this study.

- *Accountability*: Responsibility for one's actions to someone or to multiple parties as a result of legal, political, financial, personal, or morally-based ties (Zumeta & Kinne, 2011).
- *Adverse selection*: The existence of informational asymmetries, due to the combination of private information and self-interest of the agent, that exists prior to the contractual arrangement commencing, which can create incentive for agents to misrepresent their true abilities and motivations (Kivistö, 2007).
- *Agency problem*: Act of entering into a contract results in the principal delegating certain aspects of the decision-making process to the agent, providing an opportunity for the agent to choose self-interested actions that may be divergent when compared to the best, or desired, interests of the principal (Jensen & Meckling, 1976).

- *Behavior-oriented contract*: Relies on the monitoring of agent's actions (behaviors) and rewarding those actions, as the principal utilizes reporting requests, site visits, reviews, and evaluations as monitoring mechanisms in an attempt to overcome the agency problem in the principal-agent relationship (Kivistö, 2008; Lassar & Kerr, 1996).
- *DMUs*: Decision-Making Units (DMUs) that are typically the unit of analysis when utilizing the data envelopment analysis (DEA) analytical technique, as DMU was originally used to delineate the application of DEA methods to public institutions as opposed to the private sector (Avkiran, 2001; Banker, Charnes, & Cooper, 1984; Charnes, Cooper, & Rhodes, 1978).
- *Efficiency*: A DMU attains full (100%) efficiency if and only if no inputs or outputs can be improved without worsening other inputs or outputs (Cooper, Seiford, & Zhu, 2011).
- *Goal conflicts*: One of the primary assumptions of agency theory, goal conflicts exist when there is misalignment between the goals and/or preferences of the principal and the goals and/or preferences of the agent in a contractual relationship (Eisenhardt, 1989; Jensen & Meckling, 1976; Moe, 1984; Waterman & Meier, 1998).
- *Informational asymmetries*: One of the primary assumptions of agency theory, informational asymmetries occur when agents have more information than the principals in the contractual relationship (Eisenhardt, 1989; Jensen & Meckling, 1976; Moe, 1984; Waterman & Meier, 1998).
- *Input slacks*: Within a DEA model using an output orientation, slacks represent an over-utilization of inputs that can be reduced in order to achieve efficiency (Avkiran, 2001).

- *Master's Colleges and Universities*: Carnegie Classification for institutions awarding 50 or more master's degrees while awarding fewer than 20 research doctorates during the update year (Carnegie Foundation for the Advancement of Teaching, 2014).
- *Moral hazard*: Occurs when an agent fails to exert maximum effort in attempting to achieve the goals of the principal, which may include an agent either actively or passively avoiding his/her work responsibilities by using company time to work on personal projects (Eisenhardt, 1989).
- *Outcome-oriented contract*: Relies on incentive-based mechanisms, such as commissions and financial rewards that compensate agents for achieving agreed-upon outcomes that have the potential to reduce the agency problem by providing an incentive for the agent to align personal goals and actions with those of the principal in the principal-agent relationship (Eisenhardt, 1989; Kivistö, 2007).
- *Performance funding*: Outcome-based mechanism in which state funding is directly linked to campus performance on specified indicators, as the linkage between funding and performance is considered "tight, automatic, and formulaic" (Burke, 2005b, p. 219).

Assumptions

The underlying assumptions related to agency theory were:

1. Informational asymmetries and goal conflicts exist simultaneously in the principal-agent relationship between state government and institutions of higher education, creating the agency relationship.
2. Principals and agents are self-interested, utility maximizers that exhibit bounded rationality and are risk-averse.
3. Information is a purchasable commodity.

4. Behavior-oriented contracts are most efficient when a long-term contractual relationship exists that is characterized by high-level information systems, low goal conflict and outcome measurability, and high outcome uncertainty and task programmability.
5. Outcome-oriented contracts are most efficient when a short-term contractual relationship exists that is characterized by low-level information system, high goal conflict and outcome measurability, and low outcome uncertainty and task programmability.

The underlying assumptions related to data envelopment analysis (DEA) were:

1. DEA is able to accommodate multiple inputs and multiple outputs in a single model.
2. DEA does not require the specification of a functional form on the production function *a priori*, but allows the inputs and outputs in the data to determine, through linear programming methods, the production function.
3. DEA assumes that input and output data do not contain measurement error or noise.
4. All deviation from the efficiency frontier is due to DMU inefficiency.
5. DMUs are measured against only the peer DMUs included in the data.
6. Inputs and outputs used in the DEA estimations can be different units.
7. Inputs and outputs will be numerical and positive.
8. DMUs are homogenous and produce the same outputs from the same inputs, albeit possibly in varying quantities.

Delimitations and Limitations of the Study

The sample selected was a primary delimitation of this study. The choice to use the six public, four-year Master's universities in Arkansas, as opposed to all 10 four-year public institutions, was partly due to the homogeneity assumption within the DEA analytical framework. By restricting the sample to Master's universities, this study ensured the

homogeneity assumption would hold. The selection of institutions strictly from Arkansas stemmed from the state's adoption of its new performance-funding program in 2011. This choice was restrictive from the standpoint that the analysis ignored previous performance-based policies and programs in Arkansas, as well as performance-based programs in other states. Given that DEA is a data-driven, deterministic technique, the selection of input and output variables in the DEA model, as well as the environmental variables in the second-stage regression analysis, was delimited based on a review of the pertinent literature and the variables needed to answer the research questions posited in this study. The selection of a single output variable, number of bachelor's degrees awarded, was precipitated by the emphasis being placed on increasing the production of college graduates to meet the challenges issued by state and federal policy officials and other higher education stakeholders.

Several limitations existed in this research study. From the standpoint of agency theory, the assumption that principals and agents are self-interested utility maximizers limited the consideration that other human motivations, such as altruism, belief, respect for authority, and need for achievement and recognition, play a role in decision-making processes. Tangential to the narrow view of human motivation was the parsimonious nature of agency theory due to minimal assumptions that can be considered a limitation of agency theory when applied to the context of complex policymaking environments such as higher education.

With regard to the analytical technique used in this study, DEA assumes that all deviation from the efficiency frontier is due to inefficiency, which served as a limitation because statistical noise, such as measurement error, or stochastic factors beyond the control of the DMUs were not considered in the base DEA model. Additionally, the cross-sectional data used in this study was from the 2011-2012 academic year, as the time-lagged nature of financial data being made

publicly available through IPEDS was a limitation from the standpoint of institutions and policymakers being restricted from utilizing results of DEA analysis within the confines of decision-making processes. Given that DEA is a non-parametric, deterministic approach, this study was also limited in its generalizability, as the inclusion of different institutions and different combinations of input and output variables could shift the efficiency frontier and impact which institutions are deemed efficient, and the distance of inefficient institutions away from that frontier.

Significance of the Study

Calls for higher education institutions to increase their productivity and efficiency have rang out from Main Street to Pennsylvania Avenue, as more "attention has focused not only on what colleges and universities do, but also on how well they do it and what resources they use" (Heller, 2011, p. 2). One of the policy levers used by American states during the past 35 years has been performance-based funding. Most of the states that have passed performance-based funding legislation have experienced at least one adopt-implement-abandon-cycle during this time frame, including Arkansas, which is now in its fourth iteration of performance-funding programs (Gorbunov, 2013). The logical question to ask is, Why did Arkansas's legislators choose to re-vise and re-implement a policy lever that had failed three previous times, especially in light of numerous research studies that have shown performance-funding programs have historically had minimal, if any, impact on improving institutional outcomes? (Archibald & Feldman, 2008; Liefner, 2003; McLendon, Heller, & Young, 2005; Rabovsky, 2012; Sanford & Hunter, 2011; Sav, 2012; Shin, 2010; Tandberg & Hillman, 2014; Volkwein & Tandberg, 2008).

This study was significant from the perspective of utilizing agency theory as a conceptual framework that can couch the government-institution relationship constructed by the

performance-funding program in Arkansas as a contract between principal (government) and agent (institution). In this contractual relationship, the principal attempts to coerce the agent to modify institutional goals, objectives, and actions by linking a portion of state appropriations to the demonstrated production of outcomes designed to meet the preferred goals and objectives of the principal. While the application of agency theory to the context of higher education has increased during the past 20 years (Lane & Kivisto, 2008), few research studies have been conducted in which the principal-agent relationship within performance-funding policies has been the focus. This study served to increase the knowledge base within this specific sector of policymaking by exploring the dynamic relationship between state government and institutions of higher education within the performance-funding paradigm.

This study also made a contribution to the extant literature by concentrating on an under-addressed segment of higher education. Master's universities are rarely the focus of studies in the higher education literature, so the selection of Master's universities as the population under study expanded the collective understanding related to how these types of institutions function from an efficiency standpoint that has received minimal attention in the literature (Henderson, 2009). The findings from this research have the potential to be utilized by policymakers in the state of Arkansas who seek to improve the existing performance-funding program, as well institutional administrators functioning as sub-agents who are attempting to increase efficiency and productivity that will lead to achievement of the goals and objectives of the performance-funding program.

Based on an extensive review of the literature, it appears that this study was one of the few that has utilized data envelopment analysis in the evaluation of Master's institutions in the United States (Sav, 2012). To my knowledge, it may be the first research to apply Simar and

Wilson's (2007) double-bootstrap, two-stage truncated regression approach within the context of higher education in the U.S. From a methodological perspective, this study was significant in that it added to the international literature that has utilized one of Simar and Wilson's (1998, 1999, 2000, 2007) bootstrap techniques in estimating the efficiency of higher education institutions (Johnes, 2006; Lee, 2011; Parteka & Wolszczak-Derlacz, 2013; Wolszczak-Derlacz & Parteka, 2011). The results of this study, which included comparative estimates of institutional efficiency for the Master's universities in Arkansas, as well as determinants of the impact of environmental variables on institutional efficiency, have the potential to be useful to policymakers as an additional metric that can fill a gap in the existing performance-funding program; to campus administrators at inefficient universities seeking to identify peers at the national level from which to learn regarding best practices associated with institutional efficiency; to taxpayers and families concerned with whether the institutions they are supporting, through taxes or tuition, are converting inputs to outputs as efficiently as possible.

Conceptual Framework of the Study

Agency theory served as the conceptual framework utilized in this study. At its core, state governments (principals) utilize performance funding as a mechanism to incentivize desired actions of institutions (agents) to achieve objectives that are aligned to the government's (principal's) goals. Agency theory assumes that both the principal and agent are self-interested, utility maximizers who are risk-averse and make decisions that exhibit bounded rationality (Eisenhardt, 1989). According to agency theory, contractual relationships between principals and agents consist of an agency problem that results from the principal relinquishing certain aspects of the decision-making process to the agent, which provides the agent to act opportunistically in ways that may be divergent from the best, or desired, interests of the principal (Jensen &

Meckling, 1976). Agency theory contends that this agency problem stems from the concurrent existence of two constructs: informational asymmetries and goal conflicts, both of which benefit the agent (Moe, 1984). Informational asymmetries occur when the agent has more and better information than the principal, which the agent utilizes to benefit his or her self-interests, while goal conflicts relate to an incongruity between the principal's goals and objectives and those of the agent. These components, informational asymmetries and goal conflicts, must exist in order for a principal-agent agreement to be considered an agency relationship within the conceptual framework of agency theory.

At its core, agency theory is concerned with the measures taken by principals in overcoming the agency problem, as a simple characterization of the agency problem is the principal "insuring that the agent does in fact act for the principal" (Mitnick, 1975, p. 27). Principals design and implement monitoring and incentive structures that attempt to mitigate the potential for issues associated with informational asymmetries, including adverse selection and moral hazard. Adverse selection occurs when agents misrepresent their experience, abilities and motivations prior to entering into a contract with the principal, while moral hazard (or shirking) occurs during the contractual period and refers to when agents fail to exert maximum effort toward achieving the goals of the principal (Eisenhardt, 1989; Kivistö, 2007; Lane, 2012; Moe, 1984). In agency theory, the monitoring activities enacted by a principal are essentially attempts to decrease informational asymmetry by requiring agents to provide information that may otherwise not be accessible to the principal (Kivistö, 2007).

Eisenhardt (1989) argued that principals can utilize two types of contracts when attempting to address the agency problem: outcome-oriented contracts and behavior-oriented contracts. Outcome-oriented contracts seek to link an agent's compensation with the

achievement of specified performance outcomes, while behavior-oriented contracts attempt to monitor and reward an agent's actions toward achieving the principal's goals and objectives (Eisenhardt, 1989; Kivistö, 2008; Lassar & Kerr, 1996). Eisenhardt (1989) developed a taxonomy comparing the two types of contracts along seven variables that can be used to predict when each type of contract will be most efficient to implement. Table 1 below shows the variables included in Eisenhardt's (1989) taxonomy and details the differences between outcome- and behavior-oriented contracts based on a high-low dichotomy.

Table 1

Variables affecting the efficiency of behavior-oriented vs. outcome-oriented contracts

	Behavior-based contract is efficient when:	Outcome-based contract is efficient when:
Information systems	High	Low
Outcome uncertainty	High	Low
Risk aversion	Agent	Principal
Goal conflict	Low	High
Task programmability	High	Low
Outcome measurability	Low	High
Length of Relationship	Long	Short

Sources: Eisenhardt (1989) and Lassar & Kerr (1996)

In this research study, the principles of agency theory, including Eisenhardt's taxonomical representation of outcome- and behavior-based contracts typical of agency relationships, were applied to the context of performance-funding policies in higher education. Through the lens of agency theory, this study examined the adoption of a performance-funding program for the fourth time in Arkansas's history of higher education policy.

Summary

This chapter addressed the context of the research problem, the purpose of the study, research questions, definitions, assumptions, delimitations and limitations, significance, and the conceptual framework to be used in this study. This research filled a gap in the literature related to state governments utilizing performance-funding programs as a means of incentivizing increased performance and efficiency, while also informing stakeholders in Arkansas pertaining to the institutional efficiency of the Master's universities included in this study. The next chapter provides an overview of the literature relating to higher education funding, Master's Colleges and Universities, performance funding, agency theory, and data envelopment analysis. This will be followed by the methodology chapter that outlines the sample, research design, data collection, variables, and data analysis processes that were used to analyze the research question in this study. The fourth chapter will be comprised of the results of the study, while the final chapter will consist of a discussion of the findings and conclusions of this research study.

CHAPTER II

LITERATURE REVIEW

Two libraries served as the primary resources for collecting the works cited in this literature review. The Mullins Library at the University of Arkansas and the Mabee Learning Center at Oklahoma Baptist University provided the majority of the electronic and in-print texts reviewed in this chapter. Numerous articles and books were supplied through the use of interlibrary loan at both the Mullins Library and the Mabee Learning Center. The literature search for articles related to the analytical technique used in this study was facilitated by the Data Envelopment Analysis publication database (Gattoufi, Becker, Chandel, & Sander, n.d.). Google Scholar (scholar.google.com) was utilized throughout the literature search for additional resources not available through the libraries mentioned above. The primary search terms used with the electronic searches included performance-based funding, higher education, principal-agent theory, data envelopment analysis, bootstrap, and two-stage DEA.

A review of literature pertaining to performance-based policymaking indicated that American higher education is in a period of transition. This shift has been keyed by states moving from initial performance funding 1.0 (PF 1.0) policy mechanisms, which primarily involved proportionately small bonuses added to state base funding, to performance funding 2.0 (PF 2.0) models that link a percentage of base funding to a variety of institutional outcomes (Burke & Associates, 2005; Dougherty & Reddy, 2013; Jones & Snyder, 2012). Arkansas is an example of a state that has transitioned to the new era of performance-funding programs, as Arkansas' higher education sector has previously experienced a number of adopt-implement-abandon cycles since its initial performance-funding policy adoption in 1995 (Gorbunov, 2013). In order to better understand the context within which Arkansas has renewed its interest in

performance-funding policy, this chapter surveys the extant literature detailing the factors contributing to the adopt-implement-abandon cycle that has typified PF 1.0 programs, as well as explores the various reasons why numerous states have adopted/re-adopted performance-funding models within the second generation performance-funding paradigm.

Performance-funding policies are designed as a governmental agency's attempt to incentivize institutional change that leads to increased outcomes. In the case of performance-funding policy in higher education, a contractual relationship exists between the state (principal) and its public colleges and universities (agents) to produce outputs (graduates). Given the contractual nature of states and institutions of higher education, principal-agent theory provides a lens through which performance funding can be examined. At its core, principal-agent theory addresses the resolution of two key problems associated with this contractual agreement: the agency problem and the risk sharing problem (Eisenhardt, 1989). This chapter will provide an overview of principal-agent theory while explicating how the primary agency and risk sharing problems are applicable within the existing performance-funding program in Arkansas.

The latest iteration of performance-funding policy in Arkansas consists of a variety of mandatory, compensatory, and optional measures of institutional performance. However, although the term "efficiency" is included directly in the title of the legislation, the implemented policy has no specific means to account for an institution’s efficient utilization of resources (inputs) in achieving the objectives (outputs) of the policy. This study proposes the use of data envelopment analysis (DEA) as an analytical approach for estimating the efficiency of public four-year Master’s institutions in Arkansas relative to similar institutions from a national sample of Master’s Colleges and Universities. This chapter will explore recent developments in the application of DEA to higher education contexts in order to estimate efficiency of colleges and

universities, including discussing techniques that have been developed to overcome perceived deficiencies within the base DEA methodology.

This literature review will be comprised of five major sections with accompanying subsections and a chapter summary: challenges facing Master's Colleges and Universities, overview of public higher education funding, performance-funding policy, agency theory, data envelopment analysis, and a chapter summary.

Challenges Facing Master's Colleges and Universities

The institutions being examined in this study include the six four-year public universities in Arkansas that are classified as "Master's Colleges and Universities" in the Carnegie system updated in 2005 (Carnegie Foundation for the Advancement of Teaching, 2014). This sample will include Arkansas State University, Arkansas Tech University, Henderson State University, Southern Arkansas University, University of Arkansas at Monticello, and University of Central Arkansas. The collective term used to describe this general level of institution has been "comprehensive universities," stemming from the designation provided by the Carnegie Foundation in previous iterations of the Carnegie system (Carnegie Foundation for the Advancement of Teaching, 2000). Throughout the following discussion, various phrasings of the terms "comprehensive universities" and "Master's Colleges and Universities" will be used interchangeably.

The six Arkansas institutions were compared to the population of 270 four-year public Master's Universities and Colleges in the United States, as this category is disaggregated into three levels: larger programs (171 institutions), medium programs (61 institutions), and smaller programs (38 institutions) (Retrieved from http://nces.ed.gov/ipeds/datacenter/). These designations are based on the number of master's degrees awarded combined with fewer than 20

research doctorates awarded during the update year (Carnegie Foundation for the Advancement of Teaching, 2014). Institutions awarding 50-99 master's degrees are classified as smaller programs; medium programs are those institutions awarding 100-199 master's degrees; and institutions awarding at least 200 master's degrees are designated as larger programs (Carnegie Foundation for the Advancement of Teaching, 2014).

This segment of higher education was selected for several reasons, one of which is that Master's universities are rarely the focus of studies in the extant higher education literature (Henderson, 2009). Four-year public Master's universities comprise more than 47% (270 of 571) of all four-year public institutions in the United States, while awarding 36% of all bachelor degrees granted in the U.S. by four-year public institutions (Retrieved from http://nces.ed.gov/ipeds/datacenter/). While public higher education institutions educate approximately 80% of all college students and 65% of all four-year college students (Ehrenberg, 2007a), Master's institutions educate 36% of all students enrolled in four-year public institutions (Statistics calculated from "Basic Classification: Enrollment by classification category and control" table, (Carnegie Foundation for the Advancement of Teaching, 2014)).

Comprehensive institutions also face challenges related to improving performance outcomes, as the average retention rate at four-year public Master's institutions trails that of four-year public doctoral/research institutions by almost 8% nationally (70.24% and 78.11%, respectively), while graduation rates are more than 12% lower for four-year public Master's campuses in comparison to four-year public doctoral and research institutions nationally (42.55% versus 55.11% respectively) (Retrieved from http://nces.ed.gov/ipeds/datacenter/). In Arkansas, the average retention rate for the six Master's institutions in this study is 56.5%, while the average graduation rate is 32.94% (Retrieved from http://nces.ed.gov/ipeds/datacenter/).

Institutional Identity

One of the primary challenges facing comprehensive universities is related to institutional identity. The rapid growth in size, structure, and mission of comprehensive universities during the past four decades has led to institutions "struggling to attain a consistent mission that distinguishes them from the doctoral universities and liberal arts colleges" (Henderson & Buchanan, 2007, p. 523). From 1973 to 2000, the number of Master's Colleges and Universities grew by 34% (456 in 1973 to 611 in 2000), which can be compared to a 51% growth in the number of doctoral/research universities (173 in 1973 to 261 in 2000) and a 15% decline in the number of baccalaureate colleges (721 in 1973 to 606 in 2000) (Carnegie Foundation for the Advancement of Teaching, 2000). The expansion in the number of doctoral/research universities has impacted comprehensive institutions in the form of "mission creep," which occurs when comprehensive institutions attempt to "remake themselves in the image of prestigious universities" (Gonzales, 2012, p. 338).

In their original formation, public Master's Colleges and Universities were teacher's colleges or normal schools that had as their primary mission the education of future teachers (Henderson, 2009; Kassiola, 2007). This mission resulted in faculty members' primary responsibilities consisting of heavy teaching loads coupled with service within the community, as "mission creep" has resulted in institutions increasing expectations related to faculty research and publications (Henderson & Buchanan, 2007). Wright et al. (2004) called comprehensive universities "greedy institutions" for the expanding demands placed on faculty during the past few decades. Even though administrators have sought to re-mission comprehensives in the vein of research institutions, the fierce competition for federal research funding, which is largely reputation-based, restricts the access to funding at the levels necessary to increase the level of

prestige associated with Master's universities (Henderson, 2009). The existence of mission creep has led to faculty members expressing lower levels of job satisfaction compared with colleagues at other institutional types, especially during the early stages of their career in which the preparation received during research-based graduate studies is incongruous with the heavy teaching loads and service expectations found at Master's Colleges and Universities (Henderson & Buchanan, 2007).

Financial Challenges

An additional challenge facing Master's Colleges and Universities pertains to financial disadvantages in comparison to doctoral/research universities, as "certain public universities have stronger student demand, wealthier alumni, or a better research infrastructure than other public institutions" that will allow them to "generate greater revenue from alternative sources" (Cheslock & Gianneschi, 2008, p. 209). While higher education's share of total state appropriations has steadily declined during the past 30 years, primarily due to increased appropriations to support Medicaid (Delaney & Doyle, 2007; Ness & Tandberg, 2013; Okunade, 2004; Rizzo, 2006), there is competition between types of postsecondary institutions within public higher education (McLendon, Mokher, & Doyle, 2009). This competition is due, in part, to the impact increased state funding can have on the institution, as a $1,000 increase in state appropriations per FTE can produces a one percentage point increase in an institution's graduation rate (Zhang, 2006). In one of the only studies to examine the determinants of differential state appropriations by type of institution within states, McLendon, Mokher, and Doyle (2009) found that Carnegie-classified research institutions across 46 states received an average of $2,549 more in state appropriations per FTE than public non-research institutions (Master's and baccalaureate colleges) in the state during the 2003-2004 academic year ($8,261

versus $5,712, respectively). Applying Zhang's (2006) ratio from above, the $2,549 average difference in state funding per FTE equates to an additional 25 graduates per 1,000 students enrolled at research institutions. The decrease in state funding also impacts comprehensive institutions from the standpoint of increased privatization requirements. Many Master's institutions lack the capacity to diversify funding sources in the form of tuition increases, which may not be supported by market forces, or increase endowments and annual alumni funding streams (Ehrenberg, 2007b).

Academic Challenges

In addition to the identity and financial challenges faced by comprehensive institutions, academics also serve as an obstacle for Master's universities. Specifically, comprehensive colleges and universities have experienced an increase in the number of students from underrepresented populations, as well as the number of students who enter college academically underprepared (Wright et al., 2004). These students, along with first-generation students, comprise a category of students who are considered more "at-risk" for not persisting and graduating from college (Suzuki, Amrein-Beardsley, & Perry, 2012). Underprepared students are often placed in remedial/developmental courses, based on results of entrance examinations such as ACT, SAT, COMPASS, and ACCUPLACER (Fields & Parsad, 2012), that can negatively impact students from the perspectives of consuming time/resources and increasing discouragement, while failing to promote educational outcomes such as persistence and completion of a college degree (Bailey, Jaggars, & Scott-Clayton, 2013). Underprepared students pose a practical concern for Master's universities, as these students require additional attention, time and resources of faculty, which reinforces the concept of comprehensive institutions being "teaching universities" due to the "substantial number of their students (who) are less well-

prepared than the undergraduates who are attracted by and admitted to flagship institutions (Henderson, 2009, p. 186). With non-selective public institutions, including comprehensive universities, providing the bulk of remediation across higher education, students underprepared for the rigors of credit-bearing courses pose a challenge for Master's universities in comparison to their doctoral/research university counterparts (Bettinger & Long, 2009).

Overview of Public Higher Education Funding

The funding of public institutions of higher education has historically been based on inputs going into the university, including student enrollment and credit hours attempted by students, as opposed to outputs produced by the university, such as retention rates, course completions, and number of credentials awarded (Rabovsky, 2012). This input-oriented focus of funding has been progressively shifting during the past 35 years as states have adopted performance-funding policies that link specified portions of state funding to the achievement of pre-specified performance indicators (Burke, 2002, 2005b; Dougherty et al., 2014; Shin, 2010). The increased usage of performance-funding programs at the state level has occurred during a decades-long transition for funding of public higher education in general.

One of the primary trends in higher education funding during the past 25 years has been a shift in responsibility for paying for college, as students and families have increasingly assumed a larger share of educational costs due to rising tuition and decreasing state appropriations (John & Parsons, 2005). During a period when full-time equivalent (FTE) enrollment in U.S. colleges and universities has increased from 7.3 million in 1988 to 11.3 million in 2013 (SHEEO, 2014), educational appropriations per FTE have decreased to the point that, "Many public institutions have started to describe themselves as state-assisted rather than state-supported" (Hossler, 2004, p. 150). As shown in Figure 2, educational appropriations per full-time equivalent (FTE) have

decreased from $8,579 in 1988 to $6,105 in 2013 (in constant 2013 dollars), while net tuition revenue per FTE has increased from $2,685 to $5,475 during that same time span nationally (SHEEO, 2014). Net tuition revenue is defined as, "The gross amount of tuition and fees, less state and institutional financial aid, tuition waivers or discounts, and medical student tuition and fees…(that) reflects the share of instructional support received from students and their families" (SHEEO, 2014, p. 11).

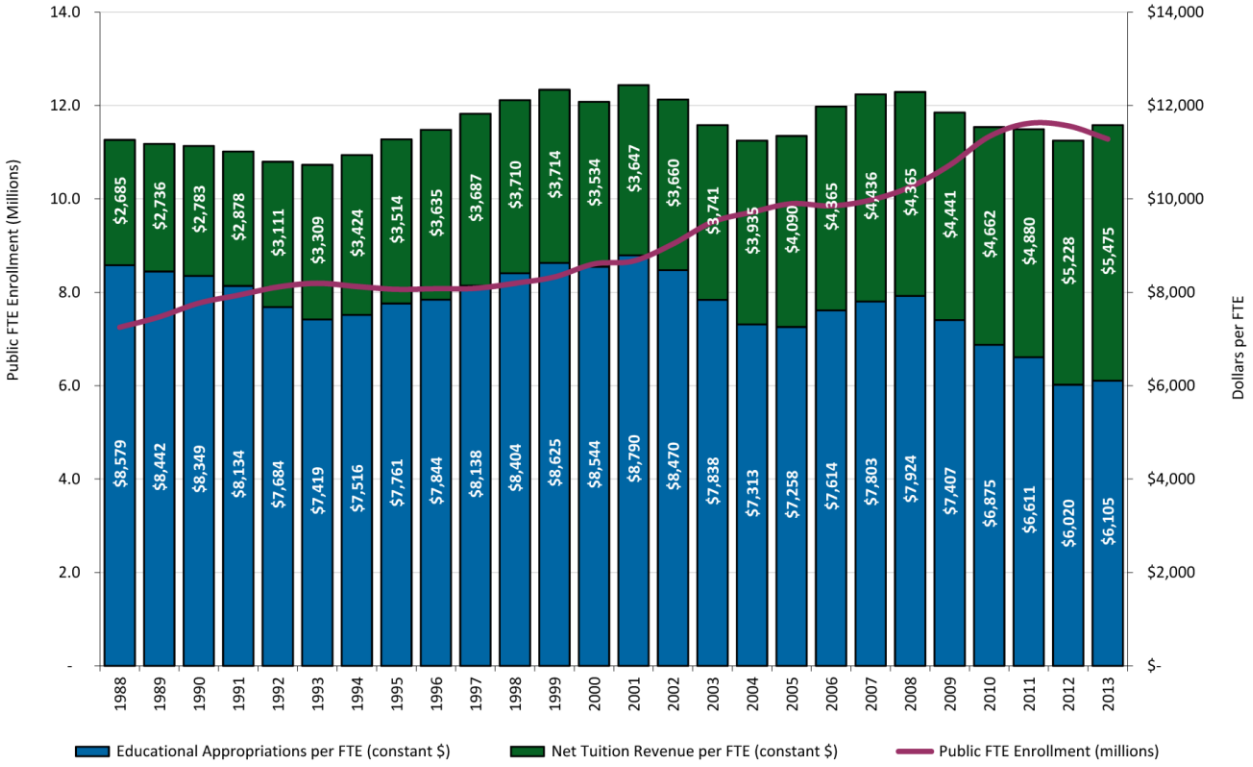


Figure 2. Public FTE Enrollment and Educational Appropriations per FTE, U.S., Fiscal 1988-2013. Constant 2013 dollars adjusted by SHEEO Higher Education Cost Adjustment (HECA). Adapted from "State Higher Education Finance: FY 2013," State Higher Education Executive Officers, 2014, p. 18. Copyright 2014 by State Higher Education Executive Officers. Reprinted with permission.

Proportionally, net tuition revenue per FTE at U.S. institutions grew from accounting for 23.8% of the $11,264 (constant dollars) average cost per FTE of enrollment in public four-year institutions in 1988 to 47.5% of the $11,580 (constant dollars) average cost per FTE of enrollment in public four-year institutions in 2013 (SHEEO, 2014). In Arkansas, educational

appropriations per FTE decreased from $7,961 in 2008 to $6,173 in 2013 (constant adjusted 2013 dollars), as the share of educational appropriations accounted for by net tuition revenue increased from 51.2% ($4,075) in 1988 to 61.0% ($3,763) in 2013 (SHEEO, 2014).

The trend of an increasing proportion of educational appropriations stemming from tuition revenue has been coupled with a general increase in the "sticker price" of college during the past three decades (Heller, 1997, p. 632). Since 1973-74, the average cost for tuition and fee charges at public four-year institutions in the U.S. has increased from $2,710 (in constant 2013 dollars) to $8,893 in 2013 (in constant 2013 dollars), representing a 228% increase (Baum & Ma, 2013). During the past decade, tuition and fee charges have increased by 41% nationally ($6,322 in 2004-2005 to $8,893 in 2013-14) (Baum & Ma, 2013). In Arkansas, tuition and fees at public four-year institutions increased from an average of $5,650 in 2004-2005 to $7,238 in 2013-2014, representing a 28% increase (Baum & Ma, 2013).

While tuition and fees have been increasing along with a greater share of college costs being shifted to students and families, another trend in higher education funding has been the decline in the proportion of state support for public institutions in relation to a state's total spending during the past three decades. Based on the National Association of State Budget Officers annual State Expenditure Reports since the mid-1980s, the highest portion of higher education's share of state general fund expenditures was in 1986, as the higher education share was just over 17% (Tandberg, 2010a). As seen in Table 2, the steady decline in higher education's share of state general fund expenditures began in 1988, essentially flattening out during the past decade before a low of 9.9% in FY 2013 (NASBO, 1997, 2013).

Table 2

Comparison of Shares of State Spending, General Funds, Fiscal 1988 to 2013

Fund Type & Year	Higher Education	Elementary\ Secondary Education	Medi-caid	Corrections	Public Assistance	Transpor-tation	All Other
FY 1988	15.5	34.2	8.7	5.2	5.3	1.3	29.7
FY 1989	15.2	34.5	9.0	5.3	5.1	1.3	29.7
FY 1990	14.6	33.5	9.5	5.5	4.9	1.3	30.8
FY 1991	14.1	33.4	10.5	5.7	5.3	1.1	29.9
FY 1992	13.5	34.0	12.1	5.6	5.1	0.8	28.8
FY 1993	13.1	34.8	13.3	5.7	5.1	0.9	27.2
FY 1994	13.0	33.9	14.2	6.2	4.9	0.9	27.0
FY 1995	12.9	33.4	14.5	6.7	4.4	0.7	27.4
FY 1996	12.9	34.4	14.8	6.9	3.9	0.6	25.6
FY 1997	13.0	34.5	14.6	6.8	3.6	0.8	26.7
FY 1998	13.1	35.2	14.8	6.9	3.0	0.7	26.4
FY 1999	12.4	35.7	14.4	7.0	2.7	0.9	26.7
FY 2000	12.8	35.7	14.4	7.0	2.7	0.9	26.7
FY 2001	12.7	35.2	15.2	6.9	2.3	1.2	26.6
FY 2002	12.4	35.1	15.8	6.9	2.3	0.7	25.9
FY 2003	12.5	35.8	17.2	7.2	2.3	0.6	24.5
FY 2004	11.7	35.8	16.9	7.0	2.3	0.5	25.8
FY 2005	11.6	35.4	17.1	6.9	2.2	0.5	26.2
FY 2006	11.3	34.4	17.4	6.7	2.1	0.8	27.2
FY 2007	11.0	34.1	16.6	6.8	2.0	1.1	28.4
FY 2008	11.7	35.0	16.0	7.0	1.9	0.8	27.6
FY 2009	11.5	35.2	16.3	7.2	1.9	0.7	26.8
FY 2010	11.5	35.5	14.8	7.4	1.9	0.7	28.1
FY 2011	11.3	35.3	16.5	7.3	1.9	0.5	27.3
FY 2012	10.1	34.8	19.3	6.9	1.5	0.5	26.9
FY 2013	9.9	35.1	19.0	6.8	1.5	0.6	27.2

Source: NASBO (1997, 2013)

The category of expenditures that demonstrated growth during this time period was Medicaid, which experienced a 118% increase from 8.7% of state general fund expenditure in 1988 to 19.0% in 2013, while higher education's share decreased by 36% during that time period (NASBO, 1997, 2013). Extant research has shown that the share of state spending on Medicaid has had a significant negative impact on general fund expenditures for higher education at the

state level (Delaney & Doyle, 2007; Ness & Tandberg, 2013; Okunade, 2004; Rizzo, 2006; Tandberg, 2010b), as "state lawmakers may see higher education as a resource they can siphon when needed" due to its capacity to raise tuition and fees (Tandberg, 2010a, p. 418). Other factors that have contributed to the share of general fund expenditures on higher education include the professionalism of the legislature, which is positively associated with increased allocations to higher education (McLendon, Hearn, & Mokher, 2009; Ness & Tandberg, 2013; Squire & Hamm, 2005; Tandberg, 2010a, 2010b); legislative party in control, as a greater portion of Democratic legislators typically results in an increase in higher education spending (Archibald & Feldman, 2006; Kane & Orszag, 2003; McLendon, Hearn, et al., 2009); and gubernatorial control, as higher education's share of state funding has been found to be lower under Republican governs (Archibald & Feldman, 2006; McLendon, Hearn, & Deaton, 2006; McLendon et al., 2005; Nicholson-Crotty & Meier, 2003).

An outgrowth of the reduction in state support of higher education has been the expansion of privatization, as the general argument has been made that if "public authorities will not provide adequate funds to sustain quality institutions and their growth to meet new student demands, then colleges and universities should seek more private resources" (Zumeta, 2004, p. 94). Therefore, privatization represents a shifting of institutions' principal funding from state funds to non-state sources (Whitney, 2006). These non-state sources consist of, in part, student tuition and fees, contracts for services and grants, private donations (Zemsky, Wegner, & Iannozzi, 1997), and "quasi-commercial ventures such as technology licensing or equity investments in spin-off companies" (Zumeta, 2004, p. 95). (Ehrenberg, 2006) argued that policies constructed to support privatization have been based on the view that "forcing the publics to behave more like the privates and compete for resources will lead to increased

efficiencies and the elimination of waste" (p. 49). Due to this move toward privatization, "The state has transitioned from a primary funding source to a major donor among many other major donors" (Whitney, 2006, p. 45).

Several consequences have stemmed from the privatization movement in higher education. Universities, especially flagship institutions, have sought to negotiate agreements with state governments for an increase in institutional autonomy as recompense for diminished state funding (Breneman, 1997; Ehrenberg, 2006; Morphew & Eckel, 2009; Tandberg & Ness, 2011) . Examples include institutions in California, Colorado, Massachusetts, Michigan, Ohio, Pennsylvania, Virginia and Wisconsin (Blake, 2006; Breneman & Kneedler, 2006; Ehrenberg, 2006; Flannery, 2011; Jacobs, 2006; Kelderman, 2009, 2012; Leslie & Berdahl, 2008; Yamada, 2010). Within this trend, the exchange of increased autonomy for lower state support has been expressed as public colleges and universities seeking freedom from governmental oversight that "lead(s) to inefficiencies in operations" while resulting in institutions having "freedom to make economic decisions that will improve their ability to compete with the privates" (Ehrenberg, 2006, p. 49). Privatization is also seen as a way to reduce the strain on state budgets while serving as a stabilization mechanism for long-term institutional finances (Lyall & Sell, 2006). The shift toward privatization also has the potential to impact access to higher education, especially for students from low-income families, while concerns regarding its impact on curriculum, teaching, tenure structure, and institutional mission have been expressed (Lyall & Sell, 2006; McPherson & Schapiro, 2001).

Discussing privatization in terms of a paradigm shift, Whitney (2006) indicated that "fundamental elements of higher education…would be reconsidered" (p. 43). One example includes the issue of construction and maintenance of institutional facilities. Historically,

facilities that are not supported by state funds have been regulated similarly to those projects funded by state appropriations (Whitney, 2006). However, Whitney (2006) argued that within the privatization paradigm, the source of the funding would have control. For example, facilities constructed and maintained through student fees could fall under the review and approval of students and alumni, not legislators or governing boards (Whitney, 2006). In the privatization paradigm, Whitney (2006) also discussed that institutions may elect to comply with those mandates that are funded and would consider unfunded mandates as "recommendations", which might include institutional responses to policies related to admissions, financial aid, remedial courses, distance education, and affirmative action (Whitney, 2006, p. 43).

The expansion of fundraising and university development efforts is another trend in how institutions of higher education are funded, as current fiscal realities make the addition of private funds an increasingly important portion of public institutional budgets (Nelson, 2009). Once considered a mechanism primarily for private institutions, fundraising has become a high priority for public universities seeking to off-set losses due to cuts in state funding (Hossler, 2004), serving as a cost-effective alternative means of generating revenue that can "substantially increase the amount of discretionary dollars available to institutional leaders" (Cheslock & Gianneschi, 2008, p. 210). According to the Digest of Education Statistics (NCES, 2013c), the total voluntary support for all degree-granting institutions in the United States (in constant 2010-2011 dollars) increased from $2.3 billion in 1949-50 to more than $31 billion in 1999-2000, as the annual total fluctuated between a low of $29.4 billion in 2009-2010 and a peak of $33.97 billion in 2007-2008 through the 2010-11 academic year. The 2013 version of the Voluntary Support of Education (Kaplan, 2013) indicated that total voluntary support in 2012 was $31 billion and increased to $33.8 billion in 2013. A recent survey of more than 300 chief

advancement officers, which included 44% from public colleges and universities, indicated a median planned increase of 16% in donations, with one-quarter of institutions planning for a more than 25% increase, during FY 2015 (Retrieved from http://www.academicimpressions.com/).

Performance-funding Policies in Higher Education

The policy landscape in American higher education has long been dominated by three primary constructs: affordability, access, and accountability. Affordability and access historically have been coupled as essential impediments that must be overcome for sufficient numbers of students to successfully navigate higher education. Federal policymakers began addressing affordability and access in the 1940s with the passage of the Servicemen's Readjustment Act (G.I. Bill of Rights) in 1945, which served as the first comprehensive federal direct student aid program and provided financial assistance to returning veterans to attend public or private colleges and universities in the United States (F. K. Alexander, 2001). The federal government continued to address affordability concerns with the passage of the Higher Education Act of 1965 and the Basic Educational Opportunity Grant Program (Pell Grant) in 1972, which serve as the foundation for the existing federal student financial aid system (Heller, 2011).

However, the past three decades have seen a significant shift in perception towards a greater emphasis on accountability, as "Educators and policymakers have now realized that access alone is not sufficient, and that there must be more emphasis on the successful completion of degrees and academic programs" (Breneman, 2011). Adelman (2006) put it even more directly: "The core question is not about basic 'access' to higher education. It is not about persistence to the second term or the second year following postsecondary entry. It is about

completion of academic credentials--the culmination of opportunity, guidance, choice, effort, and commitment" (p. xv).

One of the primary policy levers many states have sought to utilize in promoting an increase in outcomes has been performance-based funding. The era of Performance Funding 1.0 (PF 1.0) was ushered in by Tennessee's adoption of the Performance Funding Project in 1979. The Performance Funding Project encompassed the 23 public colleges and universities in Tennessee, and was an initiative developed by the higher education community independent of a legislative mandate (Bogue & Johnson, 2010; Lorber, 2001). Tennessee's Performance Funding Project is viewed as unique in higher education funding policy, given the process that led to the genesis of the performance-funding era, which has been cited as one of the primary reasons why Tennessee's Project has remained uninterrupted since its inception 35 years ago (Bogue & Johnson, 2010). In fact, Tennessee stands as the only state that adopted performance funding prior to 2000 that has continued to maintain a performance-funding program without experiencing a period of latency (Gorbunov, 2013).

Tennessee's adoption of the Performance Funding Project occurred during a time when the primary concerns related to state funding were governance structures, resource-based inputs, and the equitable distribution of state support within an expanding and diverse landscape of public institutions of higher education (Bogue & Johnson, 2010; McLendon et al., 2006). While these concerns remain in place for many in higher education, Tennessee's Project was initially implemented during a period where economic, political, and societal factors began to influence the way policymakers and the public viewed higher education. This period has been deemed the beginning of the "outcomes revolution" during the 1980s, which was defined by six key developments (Zumeta, 2011):

- Colleges and universities grew in size and expense during the recession of the early 1980s, resulting in greater scrutiny of budgetary allocations;
- Many institutions turned to business-based methods of quality improvement and cost control;
- Increase in commission reports complaining about workers' skills;
- Professionalization of state legislatures;
- President Reagan's "crusade to 'clean up the mess at Berkeley,'" which highlighted the increasing scrutiny of higher education;
- Federal government's complaints about rising costs in comparison to inflation and family incomes sparked policymakers and taxpayers to ask, "Why does college have to cost so much?" (pp. 137-138).

Even though this "outcomes revolution" was underway in America, no other states followed Tennessee's lead by adopting performance funding policies during the 1980s (Gorbunov, 2013).

As an outgrowth of the previous decade, a greater level of concern and scrutiny began to surface during the 1990s. Deemed the "new accountability" movement within the higher education policy literature, this movement was motivated, in part, by states attempting to "redefine relationships by pressuring institutions to become more accountable, more efficient, and more productive in the use of publicly generated resources" (Alexander, 2000). During this time, the focus began to shift from inputs to outcomes, as policymakers sought to establish effective governance and regulatory structures that facilitated measuring and rewarding performance of institutions (Breneman, 2011; Volkwein & Tandberg, 2008). One of the initial examples of federal policy related to increasing accountability was the Federal Student Right-to-

Know and Campus Security Act of 1991, which mandated that institutions of higher education publish graduation rate data (Archibald & Feldman, 2008).

A primary policy lever adopted by many states during this expanded emphasis on accountability in the 1990s was performance-related policies and programs. Under the "new accountability" movement, states began attempting to systematically link state-level funding to college and university performance using three primary mechanisms (Burke & Associates, 2005; Dougherty et al., 2013; Rabovsky, 2012; Shin, 2010):

- Performance reporting requires institutions to detail institutional performance, as publicity, not funding, serves as the primary lever to incentivize institutional improvement.
- Performance budgeting is a flexible, albeit uncertain, type of funding that allows governmental officials discretion in utilizing institutional performance as one measure when determining budgetary allocations to colleges and universities.
- Performance funding is an outcome-based mechanism in which state funding is directly linked to campus performance, as "Performance funding is said to have the sharpest 'teeth' because this program ties budget allocations tightly to campus performance--to the extent that campuses may actually lose funding should they fail to perform adequately" (McLendon et al., 2006).

Historically, performance reporting has been the most popular form of performance-based accountability, as more than 90% of all states have adopted some form of performance reporting policy (Burke & Associates, 2005). Recent trends have shown a shift in state policy adoption toward utilizing performance funding instead of either performance reporting or performance budgeting. Numerous lists of which states have adopted performance-funding

programs exist in the literature (Burke & Minassians, 2003; Dougherty, Natow, & Vega, 2012; Dougherty & Reddy, 2013; Gorbunov, 2013; McLendon et al., 2006; Rabovsky, 2012; Tandberg & Hillman, 2014). Depending on how the researchers have operationalized their definition of policy adoption, these lists exhibit variations. Gorbunov (2013) provided one of the most comprehensive overviews, tracing state adoption of performance funding from 1979 through 2009 across, in some cases, three different policy cycles. Gorbunov (2013) found that 27 states adopted performance funding at least once during the 30 years following Tennessee's Performance Funding Project, as Tennessee (1979) and Pennsylvania (2000) are the only two states that have not experienced at least one period of latency following the operational adoption of performance-based funding policy. In the case of Arkansas, the first policy cycle lasted from 1995-1997; the second was from 1999-2001; the third was from 2007-2008, which entered a latent period due to a lack of funding in 2008 (Gorbunov, 2013). The latest iteration of performance funding in Arkansas was introduced with the adoption of Act 1203 of 2011, as the five-year phase-in process began during the 2013-14 academic year and will culminate with full implementation in fiscal year 2018.

The Initial Era of Performance Funding

During the 35 years since Tennessee's initial adoption of a performance-based funding model in 1979, the popularity of performance-funding mechanisms has ebbed and flowed, with numerous states cycling through adopt-implement-abandon sequences. The first phase of performance-based funding policies has been broadly deemed Performance Funding 1.0 (PF 1.0), which focused primarily on providing bonuses, above and beyond base funding by states, to institutions meeting specific student outcome indicators (Dougherty & Reddy, 2013). Under most policies adopted within PF 1.0, bonus-level funding equated to 6% or less of base funding

for the successful achievement of performance indicators (Shin, 2010). Incentives have been awarded based on the achievement of student outcome indicators, input indicators, and process indicators, including graduation and retention rates, job placement rates, student transfers, licensure scores, and workforce/economic development indicators (Burke & Minassians, 2002; Burke, 2005b; Dougherty, Bork, & Natow, 2009).

A variety of reasons have been posited for the shift in policymaking that led to not only the adoption of performance-based funding policies, but also an expanding view that higher education should be held more accountable for its efficient use of resources and effective production of degreed and credentialed citizens who contribute to the economy. Brinkman & Morgan (2010) provided five primary external trends impacting colleges and universities from a financial perspective: (1) shifting demographics; (2) "new public management" strategies that focus on outputs and how revenues, expenditures, and outcomes are connected; (3) perceptual shift from higher education being a public good to higher education being a private good; (4) changing revenue streams; and (5) influence of human capital theory adoption by state governments that frames post-secondary participation and completion rates as a key economic development component (p. 6). The demise of a decades-long unwritten social compact between higher education and society has also increased calls for greater accountability. This social contract was defined by a mindset in which "Americans accepted as an unquestioned act of faith that access to a college education was a public good for society, as well as a private good for students," as one of the tenets of this pseudo-contract was that states would adequately fund public colleges and universities, using taxpayer dollars, in order to keep tuition rates at state institutions reasonably low (Burke & Associates, 2005).

In recent years, a new social compact has arisen. The defining features of this updated version include an increase in the general public's understanding of the importance of college, coupled with the views that colleges do not mainly care about students, and that institutions could reduce spending, simultaneously hold down tuition and fees, while maintaining high levels of education (Zumeta, 2011). The rise in the public's desire for policymakers to "meet society's needs without spending too much taxpayer-generated money" (Liefner, 2003, p. 470) has coincided with the perception that a college education provides more of a private benefit to the individual as opposed to benefiting society as a whole (Wall et al., 2008). A series of national surveys indicated that many Americans think that higher education is more necessary, yet less accessible to many qualified students; that institutions could increase the number of students educated while neither lowering the quality of education provided nor increasing costs for attendance; and that colleges and universities have become more corporate in nature, caring more about "the bottom line" as opposed to "making sure students have a good educational experience" (Immerwahr et al., 2010).

The Demise of First-Generation Performance-funding Policies

Beginning in the mid-2000s, American policymakers began to move away from the primary structure of PF 1.0 mechanisms. The demise of PF 1.0 policies stemmed from a collection of factors. Over the course of the first 25 years of performance-funding policies, the pervasiveness of adopt-implement-abandon cycles across the policy landscape led to a view that performance-based policies were primarily symbolic and did not represent a high-level commitment by policymakers to long-term reform (Moynihan, 2008). From the perspective of the agents tasked with implementing program changes to meet the demands of performance-

funding policies, "Public managers often rightly perceive(d) that they can simply wait things out without exerting much time or energy to redesign program activities" (Rabovsky, 2012).

In addition to the "This too shall pass" perspective, PF 1.0 policies suffered from a growing concern about the efficacy of these policies and programs. Shin (2010) found that states that had adopted performance-based accountability measures between 1997 and 2007 failed to see increases in institutional performance. Rabovsky (2012) found that performance-funding policies had been primarily ineffective in changing state budgetary practices and had minimal impacts on institutional spending priorities. Tandberg and Hillman (2014) found that performance-funding programs had no statistically significant impact on the production of bachelor's degrees during the period of 1990 to 2010. Given the complexity of institutions of higher education, and with student learning outcomes, such as graduation, typically taking years to achieve, Dougherty and Reddy (2013) argued that the relatively brief length of time that many PF 1.0 policies had been maintained could be viewed as a primary reason these policies had failed to bring about measurable changes in student learning outcomes.

In addition to the views that PF 1.0 policies were primarily short-lived, symbolic mechanisms that failed to produce increased outcomes, a variety of economic factors have played a significant role in the demise of PF 1.0. State-level funding for higher education suffered during difficult economic times for states required to meet fiscal obligations associated with other policy domains. Policymakers, tasked with meeting required funding for Medicaid, correctional facilities, and K-12 education, often view higher education as a policy arena that can withstand financial cuts given the capacity of higher education to raise additional revenue through increased tuition and fees (Heller, 2011; Immerwahr et al., 2010; Wall et al., 2008). According to Zumeta (2004), "Higher education is the largest broadly discretionary item in state

general fund budgets, so it is the most vulnerable target for budget cutting" (p. 85). Coupled with financial constraints, the instability of performance-funding levels and indicators, along with the small percentage of funds available in performance-funding programs, have also been cited as primary reasons for the demise of PF 1.0 policies (Dougherty & Reddy, 2011; McLendon, Hearn, et al., 2009). For example, with PF 1.0 programs tying 6% or less in above-base funding to institutional achievement of performance indicators, institutions may not have viewed the bonuses as being worthy of the resource expenditure required to attain the additional funds (Shin, 2010).

Second-Generation Performance-funding Policies

In part a reaction to deficiencies seen in PF 1.0, states began adopting a new form of performance funding (PF 2.0) policies around 2005. As of spring 2014, 25 states have already implemented, and five more states are transitioning to, funding models that incorporate student-level outcomes as opposed to funding models that are exclusively enrollment driven (National Conference of State Legislatures (NCSL), http://www.ncsl.org/research/education/performance-funding.aspx). Of the existing state performance-funding policies, NCSL data indicated that policies in four states include only two-year institutions; five states have policies in place for just four-year institutions; and 16 states have adopted policies which include both two- and four-year institutions.

One of the primary points of departure from first-generation programs is that new PF 2.0-type policies include performance funding as part of the state's regular base funding instead of serving as a bonus awarded above and beyond base funding levels (Jones & Snyder, 2012). The percentage of funding tied to performance is also increasing within the new policies, and quite substantially in certain instances. For example, Ohio's new performance-based funding system

has tied 50 percent of an institution's funding to student success and completion indicators, while Arkansas's new system is designed to appropriate 25% of base funding tied to performance measures by the 2017-2018 academic year (Retrieved from http://www.ncsl.org/research/education/performance-funding.aspx). While the primary outcome indicator (degree completions) has carried over from PF 1.0 policies, PF 2.0 policies have increased the emphasis placed on intermediate achievement indicators. Course completions, passage of mathematics and English gateway courses, retention and progression rates, and students surpassing course credit thresholds have been included in many PF 2.0 programs in addition to the ultimate outcomes related to student attainment of credentials found in previous performance funding programs (Offenstein & Shulock, 2010).

While many reasons for the original implementation of performance-funding programs have carried over, the intensity of these reasons has increased with the adoption of the PF 2.0 policies. Within the social contract between higher education and the American public, colleges and universities experienced a great deal of autonomy (Burke & Associates, 2005). The demise of the social contract has resulted in a shift in the policy image surrounding post-secondary accountability policy, which has driven calls from various stakeholder groups for increased external accountability, thus reducing the level of autonomy experienced by institutions of higher education. The struggle for policy image characterized as an issue of whether there is a private or a public problem that needs to be solved (Baumgartner & Jones, 2009), while Stone (1989) stated, "Problem definition is the active manipulation of images of conditions by competing political actors" (p. 299).

In relation to PF 2.0 polices, the policy image surrounding educational attainment has shifted to encompass issues related to economic growth and global competitiveness of the

American economy (Baumgartner & Jones, 2009). The impact of this change in policy image has resulted in various stakeholder groups viewing increased accountability of higher education via performance-based policies as a solution to competing in an ever-expanding global marketplace. American taxpayers have growing concern about the efficient use of fiscal resources by higher education to provide a quality undergraduate education (Nettles & Cole, 2001). Policymakers, responding to taxpayers' concerns, having increasingly grown to expect public colleges and universities to be efficient and responsive to public policy priorities and to demonstrate evidence-based impacts (Zumeta, 2011). By coupling rewards and sanctions within PF 2.0 programs, "Policymakers can provide strong incentives for public agencies to reduce or eliminate wasteful activities and to employ entrepreneurial strategies in developing new technologies and methods to improve service delivery" (Rabovsky, 2012).

Research on Impact of Performance Funding

Recent research has struggled to find significant impacts of performance-funding programs. Performance funding has been researched across a variety of domains, as studies have explored perspectives of policy innovation and diffusion, governance structures, state budgets and institutional spending patterns, retention and graduation rates, and institutional efficiency (Archibald & Feldman, 2008; Dougherty & Reddy, 2013; Liefner, 2003; McLendon et al., 2006, 2005; Rabovsky, 2012; Sanford & Hunter, 2011; Sav, 2012; Shin, 2010; Tandberg & Hillman, 2014; Volkwein & Tandberg, 2008). Even considering the extant literature, "There remain serious gaps in our empirical knowledge about the extent to which these policies are having substantive impacts on budgetary processes at the state level on service delivery at the organizational level" (Rabovsky, 2012).

Liefner (2003) conducted a series of qualitative case studies from July 1998 to October 1999 at universities in the United States (Massachusetts Institution of Technology, University of Texas at Austin), Switzerland (Swiss Federal Institute of Technology [ETH Zurich], University of Basel), the Netherlands (University of Twente), and Great Britain (University of Bristol). Liefner (2003) applied a modified principal-agent theory in studying how resource allocation through various forms of payments affected the behavior of institutional personnel across the six institutions. Operating under the assumption of "uniform human behavior," Liefner (2003) tested the following two hypotheses, guided by principal-agent theory, against empirical evidence to determine whether principal-agent theory exhibits predictive validity:

1. Agents that have been rather inactive before the introduction of performance-based resource allocation will have to work harder.
2. With performance-based resource allocation agents will tend to avoid projects with high chance of failure. Departments and individuals will concentrate on activities where success can be expected because they will have to meet a formula's criteria or market demand (pp. 478-479).

Based on interviews with 53 professors, the introduction of performance funding resulted in agents working harder, while professors reported the lack of performance funding encouraged risk-taking activities by scholars (Liefner, 2003). Further analysis indicated that professors rated faculty qualifications as being the most important factor in long-term success of universities, with the form of resource allocation and other incentives ranking below student ability/motivation and university culture (Liefner, 2003). While Liefner (2003) found that the form of resource allocation was not a factor in long-term success of universities, the author argued that performance funding could accomplish the following: "(1) force universities and

individuals to pay attention to the needs of governments and taxpayers, (2) help to adjust the organizational structures of universities more quickly to the emerging needs and opportunities, and (3) be used to re-allocate funds to those groups and scholars that have proved to be successful and to reduce the budgets of those who are not performing in an acceptable way" (p. 486).

In a study of spanning more than 20 years of higher education policymaking using data from 49 states, McLendon et al. (2005) tested eight hypotheses associated with innovation and diffusion of performance funding policy across three domains: general post-secondary policy innovation, post-secondary accountability innovation (performance funding, performance budgeting, and undergraduate assessment policies), and post-secondary financing innovation (college savings programs, prepaid-tuition programs, and broad-based merit scholarship programs). The authors' primary findings indicated that legislative control by Republicans was strongly, positively associated with general post-secondary innovation, as was the number of policy innovations adopted by neighboring states (McLendon et al., 2005). However, related to the domain that included performance funding, McLendon et al. (2005) found "the absence of virtually all hypothesized effects on state accountability innovation" (p. 380), as political context, interstate diffusion, and governance structure had minimal to no relationship with accountability policy innovation in this study.

McLendon et al. (2006) studied educational attainment in 47 states, as measured by the percentage of adults 25 and older who had completed four or more years of college, using the policy innovation and diffusion framework. McLendon et al. (2006) tested 10 hypotheses related to intra- and inter-state characteristics in order to gauge which states were more likely to adopt new higher education performance policies. Results of the event history analysis indicated that

party strength in the legislature and governance structure in higher education were the two statistically significant predictors of policy adoption out of the 10 hypotheses that were tested. For performance-funding policies, a higher percentage of Republicans in the legislature and the lack of a consolidated governing board resulted in a greater probability of policy adoption, while a lower percentage of Republicans in the legislature and a more centralized governance structure resulted in a greater probability for adoption of performance budgeting policies (McLendon et al., 2006).

Archibald and Feldman (2008) studied the graduation rates of 187 national universities, comparing the typical regression-based methodology to a production frontier approach, specifically data envelopment analysis (DEA). In conducting their comparative analysis of graduation rates, Archibald and Feldman (2008) utilized four input variables: percent of students in the top 10% of their high school class; 25th percentile SAT score; percentage of full-time faculty; and cost per undergraduate. In comparing the results of the two analytic techniques, the authors found that the correlation between residuals produced by the regression equation and the technical efficiency scores produced by the DEA was .6708. Alternatively stated, the two techniques agreed on the placement of above average and below average institutions at a rate of 79%. Of the 187 institutions in the study, the two techniques did not agree on 39 institutions. Archibald and Feldman (2008) argued that these findings support the notion that DEA is a more appropriate technique. For example, some institutions were rated above average under regression analysis, but were determined to be far below the production frontier. Such findings may be misleading to institutions, in that they might be satisfied with being above the average graduation rates in the sample, when they could be reviewing the practices of the institutions on the production frontier to determine areas for improvement in their own organization. Conversely,

institutions rated below average by the regression equation may in fact be performing well with respect to their efficient use of resources determined by the production frontier.

Shin (2010) studied the impact of performance-funding policy across 467 public four-or-more year institutions in the United States, analyzing separately the outcome measures of student graduation rates and federally-funded research expenditures. Shin (2010) collected six-year graduation rates from the Integrated Post-secondary Education Data System (IPEDS), as he also chose to use expenditures of federally-funded research contracts and grants to control for "apparent instability in funding" due to multi-year grant awards (p. 53). Shin (2010) included program variables designating the length of time performance funding had been adopted, and whether state policy consisted of performance budgeting, performance funding, or performance budgeting and performance funding, along with a measure of centrality ranging from low centralized (neither mandated programs nor prescribed indicators) to highly centralized (mandated programs with prescribed indicators). The author found that the growth of graduation rates in states with performance-based funding programs was statistically significantly different than states that had not adopted any measure of performance budgeting, performance funding, or both. However, the effect size of new accountability programs was near zero, indicating that the total variance explained by the model controlling for performance-based funding type was exactly the same as when not controlling for PBF. In examining growth of research funding, Shin's (2010) research showed that states with performance budgeting programs grew more rapidly than states without such programs, although the growth rate for states with only performance funding or both performance funding and performance budgeting policies was essentially the same as states with no performance-based funding policy. Shin's (2010) overall hierarchical linear model accounted for 59% of the variance in graduation rates, as state-level

factors accounted for 15% of the graduation rate performance measure as compared to 76% of the variance being explained at the institutional level. For research funding, the state-level component accounted for less than 6% of the variance in research funding, with 82% being accounted for by the institution-level factors.

Rabovsky (2012) studied whether states' "adoption of performance-funding policies corresponds with a better link between student outcomes (graduation rates, retention, and bachelor's degrees produced) and state appropriations, and whether these policies have any noticeable effects on the way that public universities prioritize activities related to research and instruction" (p. 676). To address the first topic, Rabovsky (2012) explored the level of financial support states provided in light of other factors, such as the status of the economy and other competitors for state's finite resources. The second research goal of this study centered on the shift in resource expenditures at the institutional level to determine whether colleges moved funding away from research-driven activities to instructional-focused activities, which would support Rabovsky's (2012) causal model assumption that restructured incentives lead to an administrative response that improves outcomes in order to attain the financial resources accompanying the performance policies. Rabovsky (2012) found that performance-funding policies had been primarily ineffective in changing state budgetary practices and had minimal impacts on institutional spending priorities. Rabovsky (2012) posited that the potential remained for "policies to have considerable effects on administrative behavior if policymakers could more effectively tie larger incentives to institutional performance," which would seem to reinforce one of the tenets of PF 2.0 policies (p. 694).

In their qualitative study of three states, Dougherty et al. (2013) found that financial inducements served as the primary policy instrument utilized in performance funding 2.0, while

providing information about state goals, providing information about institutional performance, and building capacity were secondary. While Tennessee, Ohio, and Indiana each exhibited high levels of importance related to financial incentives under both PF 1.0 and PF 2.0, greater variance was seen among the states on the other policy instruments utilized (Dougherty et al., 2013). For example, building institutional capacity was viewed by interviewees as having either low or medium degree of importance as part of the espoused theory of action across the three states. In reviewing the degree of specificity related to institutional change, the three states were reluctant to include specific institutional change requirements in their performance funding structures, preferring to mandate the outcomes to be evaluated and not the means by which those outcomes should be achieved. While institutional autonomy and governmental overreach were provided as reasons for this reluctance, Dougherty et al. (2013) quoted a higher education official in Ohio as an example of another issue: "We did not know what campuses should do to achieve the performance goals. If we did know, with certainty, we would have told them. This is to acknowledge that we knew we were starting an experiment, with the goal of inducing campuses to develop new programs and policies in response to the new incentives" (pp. 27-28). The complexity of higher education institutions, coupled with potential negative reactions by institutional faculty, administrators, and staff, resulted in "ample justification for the hesitation of state officials to specify in close detail what changes colleges and universities should make" (Dougherty et al., 2013).

Tandberg and Hillman (2014) used a quasi-experimental research design in testing whether the existence of performance-funding mechanisms in states impacted the completion of baccalaureate degrees within those states. Tandberg and Hillman (2014) found that performance-funding programs had no statistically significant impact on the production of

bachelors degrees during the period of 1990 to 2010. When accounting for the interaction between performance funding and the number of years of the program, statistically significant effects of performance funding were not seen until the seventh, eighth, and eleventh years of implementation (Tandberg & Hillman, 2014). While the magnitude of these significant effects is small, as coefficients ranged from 0.035 to 0.042, their results seem to support the view (Dougherty & Reddy, 2013) that time is a critical contributing factor in the success of performance funding programs. With students typically taking four to six years to graduate from college, previous research may have failed to find significant improvements in outcomes in part due to the fact that many states abandoned their performance-funding programs long before a full cycle of students could progress through institutions after performance funding had been implemented. Of the 21 states included in this study who had adopted performance funding, just six sustained their programs for seven or more years, as six also ended their programs in three years or less (Tandberg & Hillman, 2014).

Agency Theory: Conceptual Framework of the Study

At its core, performance-funding policies serve as a mechanism by which legislatures and governing boards seek to incentivize improved institutional productivity by tying funding to performance across a variety of student outcomes, including retention, progression, graduation, and job placement rates (Burke, 2002; Conner & Rabovsky, 2011; Dougherty et al., 2013, 2011; Tandberg & Hillman, 2014). This relationship between state governments and colleges and universities can be viewed in terms of a contract (Kivistö, 2008). In exchange for resources (inputs), the agent agrees to produce outputs (graduates) as efficiently as possible in order to meet the goals and objectives of the principal (i.e., educated citizenry contributing to the

economy). The complexities inherent in this contractual relationship between the state and institutions are ideally suited for examination through the lens of agency theory.

The Development of Agency Theory

The genesis of agency theory can be found in the works of economist Adam Smith and sociologist Max Weber. In The Wealth of Nations, Smith posited that managers may have different motivations from those of the owner who hired them, while Weber contended that agents often have "specialized knowledge" that could hinder how effective the principal can be in monitoring agents' work (Lane, 2012). These constructs became more formalized through research conducted during the 1970s and 1980s in the fields of economics (Alchian & Demsetz, 1972; Arrow, 1971; Jensen & Meckling, 1976; Ross, 1973; Spence & Zeckhauser, 1971) and political science (Klitgaard, 1988; Mitnick, 1975; Moe, 1984; Rose-Ackerman, 1978). The collective research has provided a standardized definition of the principal-agent relationship as consisting of one party (principal) entering into a contractual agreement with another party (agent) with the expectation that the agent will perform specific tasks that result in achieving the desired outcomes of the principal (Moe, 1984). Within agency theory, the contract serves two primary purposes: establishing the tasks that the agent agrees to complete, and determining the agent's compensation (Mason, Slack, & others, 2003; Perrow, 1986).

In the most general terms, agency theory can be viewed as consisting of relatively minimal assumptions regarding the principal-agent relationship. Following the economic construct of Homo Economicus, agency theory assumes that both principals and agents are individuals acting as rational, self-interested maximizers (Ghoshal, 2005). Much of agency theory has focused on agents who engage in self-interested actions that are misaligned with the goals and desires of the principal and result in a decrease in the outcomes or utility of the

principal (Eisenhardt, 1989; Jensen & Meckling, 1976; Mason et al., 2003). In order for an agency relationship to exist, two additional components must be present at the same time: informational asymmetries and goal conflicts (Moe, 1984), as Waterman and Meier (1998) characterized these two elements as the "spark plugs that power (agency) theory" (p. 177). Informational asymmetry occurs when the agent knows more about his own abilities, expertise, and honesty than the principal, as Shapiro (2005) contended that an agent "sometimes makes matters worse by exaggerating talents" (p. 263). Within institutions of higher education, informational asymmetries exist at multiple levels due to the complexities of the organizational structure and the specialized expertise required in the academic work of teaching and research (Kivistö, 2008). Goal conflicts occur when the interests and desires of the principal and agent are misaligned (Kivistö, 2005). The combination of informational asymmetries and goal conflicts provide an opportunity for agents to shirk their contractual responsibilities, which is the essence of the agency problem addressed by agency theory (Waterman & Meier, 1998). Table 3 provides an overview of the defining constructs of agency theory (Eisenhardt, 1989).

Table 3

Agency Theory Overview

Construct	Description
Key idea	Principal-agent relationships should reflect efficient organization of information and risk-bearing costs
Unit of analysis	Contract between principal and agent
Human assumptions	Self-interest Bounded rationality Risk aversion
Organizational assumptions	Partial goal conflict among participants Efficiency as the effectiveness criterion Information asymmetry between principal and agent
Information assumption	Information as a purchasable commodity
Contracting problems	Agency (moral hazard and adverse selection) Risk sharing
Problem domain	Relationships in which the principal and agent have partly differing goals and risk preferences (e.g., compensation, regulation, leadership, impression, management, whistle-blowing, vertical integration, transfer pricing)

Source: Eisenhardt (1989, p. 59)

Unlike other theories or theoretical frameworks, agency theory has not resided within one specific academic/scholarly discipline or paradigm (Kivistö, 2008). In his exploration of the differences between the application of agency theory across disciplines, Kiser (1999) compared the main characteristics of agency theory as developed in economics, political science, and sociology. Table 4 shows that economic and political science implementations of agency theory appear to be more similar, while agency theory in sociology is generally more diverse (Kiser, 1999). For the purposes of this study, only developments in economic and political science forms of agency theory will be considered.

Table 4

Main Characteristics of Agency Theory in Economics, Political Science, and Sociology

Characteristic	Economics	Political Science	Sociology
Microfoundations	Parsimonious, rationality and self-interest; also include risk	Parsimonious, rationality and self-interest	Ranges from parsimonious to broad; often include values
Meso Level: Organizational Structure	Sparse or absent; some include multiple agents	Sparse; some include multiple principals	Several ideal types of organizational structures; include both multiple principals and multiple agents
Macro Level: Structural Context	Sparse or absent	Sparse or absent	Very full; all incorporate "material" structure, many include culture as well

Source: Kiser (1999, p. 148)

Within economic agency theory, two separate, but complementary streams have developed: positivist theory of agency and principal-agent theory that overlap in a variety of ways (Eisenhardt, 1989). According to Jensen (1983), "Both literatures address the contracting problem between self-interested maximizing parties and both use the same agency cost minimizing tautology (although not necessarily stated in that form)" (p. 334). The streams also have commonalities related to "assumptions about people, organizations, and information" (Eisenhardt, 1989, p. 59), while also focusing on the principal-agent contract as the unit of analysis (Kivistö, 2007). While sharing components, the two streams also consist of divergent characteristics. The literature developed under principal-agent theory tends to be viewed as more abstract and mathematical while exhibiting a non-empirical orientation in comparison to the non-

mathematical, empirically oriented positivist theory of agency literature (Eisenhardt, 1989; Jensen, 1983; Kivistö, 2007).

The two streams also diverge in the particular focus of the theories. Positivist agency theory is primarily concerned with "identifying situations in which the principal and agent are likely to have conflicting goals and then describing the governance mechanisms that limit the agent's self-serving behavior", while principal-agent theory focuses on determining which "contract is most efficient under varying levels of outcome uncertainty, risk aversion, information, and other variables" (Eisenhardt, 1989, pp. 59-60). Even though differences exist, Eisenhardt (1989) argued that the two streams can be considered complementary in that positivist theory of agency can identify alternative contract scenarios which can then be viewed through principal-agent theory to determine the optimal contract for the specific instance. To this end, Eisenhardt (1989) developed a taxonomy comparing behavior-based and outcome-based contracts along with variables that can be utilized to predict contractual optimality under certain situations. This taxonomy will be explored further in a subsequent section of this chapter.

Concurrent with economic agency theory developments, political scientists applied the concepts of principal-agent relationships to explore a key Weberian concern: "[C]an elected politicians control the appointed bureaucrats who implement state policies, and if not, does the power of unelected bureaucrats threaten democracy?" (Kiser, 1999, p. 154). In political science-constructed agency theory, bureaucrats (agents) have the benefit of informational asymmetries and expertise over politicians (principals) due to being more knowledgeable of organizational needs and having context-specific expertise (Waterman & Meier, 1998). In order to combat bureaucratic shirking, politicians can utilize incentive structures when designing bureaucracies, implement monitoring procedures, and apply sanctions or rewards to overcome bureaucratic

actions not aligned with principal preferences (McCubbins, Noll, & Weingast, 1989; Mitnick, 1980; Waterman & Wood, 1993). Political scientists also view the dyadic, one-principal, one-agent assumption of economic agency theory as unrealistic in governmental agencies, allowing for multiple principals within complex organizational structures (Moe, 1984).

Recognized as one of the first political scientists to apply agency theory, Banfield (1975) explored the primary variables associated with corruption in governmental organizations through the lens of the principal-agent relationship. His analysis included a comparison of economic and governmental institutions along key elements of agency theory, finding that, "The structural features of 'typical' American governmental organization differ strikingly from those of business" (Banfield, 1975, p. 585). Banfield (1975) deviated from the economic agency model by relaxing the rational choice assumption and allowing for additional preferences of power, glory and "serving in a good cause" as part of the incentive system within governmental organizations (p. 596). This view expanded beyond the narrow focus of agent's being self-interest maximizers posited by economic streams of agency theory (Lane, 2012).

Banfield (1975) also diverged from the one-principal, one-agent concept of economic agency theory by recognizing multiple principals are often involved throughout governmental agencies, which "often makes monitoring more difficult and corruption in bureaucratic agencies higher" (Kiser, 1999, p. 154). In political science agency theory, multiple principals can extend beyond elected officials, including interest groups, federal agencies, media, and public opinion (Waterman & Meier, 1998). The influence of multiple principals often occurs through informal arrangements, in addition to formal contracts that are key to economic agency theory, in governmental organizations, as officials informally work with other officials, interest groups, and

voters "in order to assemble the authority they require to maintain and if possible increase their power" (Banfield, 1975, p. 597).

In his seminal article of political science-based agency theory, Moe (1984) further addressed differences between applications of agency theory in business-centric economic terms and bureaucracy-focused political science terms. In general, Moe (1984) argued that the incentive structures in business settings that reward agents with pecuniary (salaries, profits, fringe benefits) gains do not exist in public bureaucracies, where agents have minimal expectation they will have a "share of the 'profit' in partial payment for their effort" (p. 763). While economic agency theory posits self-interest financial gain as the primary motivator for agents, Moe (1984) expanded the motivators associated with bureaucratic behavior to include the concepts of budgets, slack, policy, career opportunities, and security as motivating factors for agents in bureaucracies. The hierarchical control and complexity of bureaucracies also differentiates the economic and political science views of agency, as different "types" of bureaucrats will focus on control mechanisms that achieve different ends, depending on the salience of motivational elements within their given context (Moe, 1984). The existence of exogenous entities that can place constraints on principals and agents within the bureaucratic organization, such as being able to "dictate bureaucratic goals, impose internal structures, require reorganization, set resource levels, and determine types and numbers of personnel," also differentiates how agency theory should be applied in the public sector versus the private sector (Moe, 1984, p. 765).

The Agency Problem

Regardless of academic paradigm, the essence of agency theory contends that the act of entering into a contract results in the principal delegating certain aspects of the decision-making

process to the agent, providing an opportunity for the agent to choose self-interested actions that may be divergent when compared to the best, or desired, interests of the principal (Jensen & Meckling, 1976). Essential to the study of the principal-agent relationship is how principals attempt to coerce or incentivize agents to make choices that will maximize the potential for achieving the principal's goals and objectives (Lane, 2012). As Lane and Kivisto (2008) stated, "This tension is one of the classic dilemmas at the heart of the principal-agent framework: how does one empower an agent to fulfill the needs of the principal, while at the same time constraining the agent from shirking on their responsibilities?" (p. 142).

At its core, agency theory attempts to deal with the agency problem in principal-agent relationships, as the agency problem stems from the existence of informational asymmetries and goal conflicts between the principal(s) and agent(s) who have entered a contractual relationship (Kivistö, 2008). The agency problem has been viewed as generally existing in all instances where organizations and cooperative behavior are involved, including firms, universities, governmental authorities, and unions (Jensen & Meckling, 1976). Agency theory assumes that informational asymmetries and goal conflicts benefit agents, as "The agent has his own interests at heart, and is induced to pursue the principal's objectives only to the extent that the incentive structure imposed in their contract renders such behavior advantageous" (Moe, 1984, p. 756).

A key concept that pertains to the agency problem is moral hazard. Moral hazard, also referred to as shirking in the literature, occurs when an agent fails to exert maximum effort in attempting to achieve the goals of the principal, which may include an agent either actively or passively avoiding his/her work responsibilities by using company time to work on personal projects (Eisenhardt, 1989). Moral hazard has typically been viewed as resulting from an agent pursuing self-interested actions that are misaligned with a principal's preferences (Lane, 2012).

More broadly termed moral hazard as "hidden action" (Pratt, Zeckhauser, & Arrow, 1985, p. 43), claiming that the term moral hazard originated in theory from the insurance sector and is relatively limited in its application beyond specific cases. In addition to moral hazard, adverse selection contributes to the agency problem due to the "unobservability of the information, beliefs, and values on which the decisions of others are based" (Moe, 1984, p. 754). Referred to as "hidden information" by Pratt et al., (1985, p. 43), Kivistö (2007) explained adverse selection as being caused by information asymmetries that exist prior to the contractual relationship commencing, as he contributed adverse selection to the combination of private information and self-interest that may "create incentives for agents to misrepresent themselves opportunistically as something that in reality they are not" (p. 19).

Addressing the Agency Problem

According to Mitnick (1975), the agency problem can simply be characterized as the principal "insuring that the agent does in fact act for the principal" (p. 27). The principal's essential problem is designing a monitoring and incentive structure, given the existence of a relationship characterized by agent-benefiting informational asymmetry and goal conflicts that will mitigate the potential for issues associated with agent-driven adverse selection and moral hazard (Moe, 1984). Essentially, monitoring by a principal is an attempt to decrease informational asymmetry by requiring agents to provide information that may otherwise not be accessible to the principal (Kivistö, 2007).

When attempting to address the agency problem, Eisenhardt (1989) argued there are two basic options for the principal within the economic agency framework: behavior-oriented contracts and outcome-oriented contracts. Behavior-oriented contracts rely on monitoring agent's actions (behaviors) and rewarding those actions, as monitoring mechanisms include reporting

requests, site visits, reviews and evaluations (Kivistö, 2008; Lassar & Kerr, 1996). Outcome-oriented contracts are incentive-based contracts that compensate agents for achieving agreed-upon outcomes (Eisenhardt, 1989). Outcome-oriented contracts, such as commission-based salaries, have the potential to reduce the agency problem by providing an incentive for the agent to align his/her goals to that of the principal while also encouraging agents to choose actions that are in the best interest of the principal as well (Kivistö, 2007).

Eisenhardt (1989) posited 10 propositions that indicated whether a particular variable is positively or negatively associated with type of contract. The first two propositions, from positivist agency theory, indicate that (1) outcome-based contracts and (2) availability of information to verify agent behavior each promote the alignment of agent choices with principal's interest and goals while reducing the opportunity for moral hazard (Eisenhardt, 1989). The remaining eight propositions, two of which address risk aversion, stem from principal-agent theory stream, and are represented in Table 1 included in Chapter 1 of this study.

While most of the variables included in the taxonomy are fairly self-explanatory, two constructs deserve further explanation. Eisenhardt (1989) introduced the concept of task programmability, which is "defined as the degree to which appropriate behavior by the agent can be specified in advance," as "the behavior of agents engaged in more programmed jobs is easier to observe and evaluate" (p. 62). High levels of task programmability support behavior-based contracts. Risk aversion is related to the extent of an individual's "preference for adventure rather than security", as it is assumed that agents are more risk-averse than principals (Kivistö, 2007, p. 17). The risk-averse nature of agents is heightened within outcome-oriented contracts, as there is uncertainty regarding the outcomes produced, and subsequently, the agent's compensation associated with those outcomes (Eisenhardt, 1989). Risk-aversion is reduced

within a behavior-based contract for both the principal and the agent, as agent insecurity is lowered regarding compensation and the principal is not faced with paying a "risk premium" to the agent (Lassar & Kerr, 1996, p. 615).

Given that Eisenhardt's (1989) taxonomy grew out of principal-agent theory, which is designed to determine the most efficient contract from available options, interpreting the taxonomy is fairly straightforward. Behavior-based contracts are most efficient in a long-term principal-agent relationship where minimal goal conflict exists, the principal can effectively monitor agent behavior through a combination of information systems and task observability (programmability). Greater outcome uncertainty, limited capacity to measure outcomes, and agent's risk aversion contribute to behavior-based contracts being preferred. In contrast, outcome-oriented contracts are more efficient when a short-term contractual relationship exists, outcomes are certain and can effectively be measured, and the principal is more risk averse. The decision to use an outcome-based contract is also more effective in situations with high levels of goal conflict between the principal and agent, along with the principal having a limited capacity to monitor agent behavior through information systems and observing tasks.

Criticisms of Agency Theory

Criticisms of agency theory have primarily centered on the narrow view of human motivation and behavior assumed to define the principal-agent relationship (Kivistö, 2007). The assumption that agents are solely motivated by the maximization of self-interest has been attacked by critics who argue for more far-reaching, complex conceptualizations of human behavior that incorporate other human motivations, such as altruism, belief, respect for authority, need for achievement and recognition, and intrinsic motivation (Donaldson, 1990). Critics also express concern related to the assumption that agents exhibit opportunistic behavior in

conjunction with self-interested motivation, as Donaldson (1990) characterized this view as being "overly generalized" and a "cynical" conception of human morality (p. 373). While offering a retort against criticisms of the motivation and behavioral assumptions, agency theory proponents concede its limitations: "Even though agency theory does not suggest that self-interest and opportunism are the only motivators of human beings, part of the problem is that the theory fails to explain the principal's utility losses by any other factor than agent opportunism" (Kivistö, 2007, p. 187).

One of the most outspoken critics of agency theory, Perrow (1986) contended the "principal-agent model is fraught with the problems of cheating, limited information, and bounded rationality in general" (p. 224), while also concluding agency theory may even be "dangerous" because "theories shape our world; they encourage us to see it in a certain way, and then we exclude other visions that direct our actions" (p. 235). Arguing from a corporate governance perspective, Ghoshal (2005) generally criticized agency theory as having "little explanatory or predictive power", consisting of "unrealistic assumptions and invalid prescriptions", and lacking "both face validity and empirical support" (pp. 80-81). Perrow (1986) also claimed that agency theory addresses no clear problems, while Schmidtlein (1999) argued that agency theory fails to account for interactions between principal and agent beyond those formally defined within economic incentives and sanctions.

Extending into political science and public policy sectors, criticisms have been levied against the simplicity of agency theory within the context of complex policymaking environments (Gerber & Teske, 2000; Koelble, 1996; Moe, 1984). The complexity of public sector organizations, in which multiple principals exist and individuals may at once operate as both principal and agent, can pose difficulties for agency theory, as "(T)he lack of ability of

agency theory to handle the possible existence of stakeholders or competing principals can indeed be considered to be a clear limitation of the theory" (Kivistö, 2007, p. 47). Lane and Kivisto (2008) also argued that agency theory has limitations, especially in the public sector where most institutions and bureaucracies do not have the capability to exit contracts with the government, because there is no "questioning the legitimacy or justification of a principal's goals or the task to be accomplished" (p. 165).

Agency Theory in Higher Education

In order to consider the government-university relationship as an agency relationship, Kivistö (2007) stated that the relationship must contain the following elements: (a) tasks which the government delegates to a university; (b) resources which government allocates to a university for accomplishing the tasks; and (c) government interest in governing the accomplishment of the tasks (p. 53). The contractual relationship consisting of these three elements provides an opportunity for informational asymmetries and goal conflicts to exist in the government-university relationship (Jensen & Meckling, 1976; Moe, 1984). When the government delegates decision-making responsibilities to the university, agency theory assumes the agents will act as self-interested maximizers with a proclivity for shirking the responsibilities outlined in the contract (Eisenhardt, 1989). Lane and Kivisto (2008) contended that the application of agency theory, and its focus on the concept of shirking, offers practical benefits for researchers in a variety of policy-related issues in higher education, including performance-based funding programs, faculty productivity, and policy implementation.

Within the agency theory literature applied to higher education, shirking is re-visioned as academic ratchet, where faculty, over time, "shift effort away from tasks such as teaching, student advising, and committee work in order to spend more time on research and other

endeavors that are more personally or financially rewarding" (Lane, 2012, p. 290). A complementary construct to academic ratchet is academic lattice, which describes how administrative staffs in universities tend to grow relative to faculty over time, and partially as a reaction to the existence of academic ratchet (Ortmann & Squire, 2000). This scenario is an example of an intra-organizational principal-agent relationship that typifies the complexities of universities, which consists of multiple agency relationships throughout the hierarchical structure typical of higher education institutions (Kivistö, 2008). Further complicating issues related to agency relationships, personnel such as deans and department chairs are at once agents and principals, as they receive assignments and budgetary allocations from superiors (agent) while being responsible for making assignments and dispensing funds (principal) in their areas of supervision (Liefner, 2003). Given the complex, hierarchical framework of higher education as a public bureaucracy, many different principal-agent relationships exist that are both endogenous and exogenous to the institution (Lane & Kivisto, 2008). The multi-layered, multiplicity of principal-agent relationships in higher education presents difficulties for classical or canonical agency theories, which is a limitation to using agency theory in the context of higher education research (Kivistö, 2008).

The second (resource allocation) and third (governing the accomplishment of tasks) elements required for the government-university relationship to be considered an agency relationship corresponds to one of the policy mechanisms state governments have used to incentivize increased institutional production of outcomes: performance-based funding. Within agency theory, performance-based funding fits within the category of outcome-oriented contracts in which principals compensate agents for achieving agreed-upon outcomes (Eisenhardt, 1989). Course completions, passage of mathematics and English gateway courses, students surpassing

course credit thresholds, and retention and graduation rates are examples of outcomes included in performance-funding models (Offenstein & Shulock, 2010). Due to the complex nature of higher education institutions, Liefner (2003) argued that principals have difficulty monitoring individual and institutional activities in the higher education sector, which has contributed to the usage of performance-based funding programs that incentivize particular institutional (agent) behaviors to meet the established goals of the principals. Outcome-based funding, in the form of performance-funding formulas, serve as an attempt to "reduce goal conflict by aligning the official and operative goals of universities with the ones of the government" (Kivistö, 2007, p. 106). When viewed as a contractual agreement between principal (government) and agent (institution), agency theory provides a lens through which performance-funding policies in higher education can be examined (Kivistö, 2008).

The use of agency theory within higher education research has increased during the past two decades (Lane & Kivisto, 2008). Prior to 2000, the application of agency theory in the higher education sector had been "only sparingly incorporated into the study of higher education. Wider application of (principal-agent theory) was seemingly ignored not only by the mainstream higher education researchers, but also economists and political scientists working in the higher education field" (Lane & Kivisto, 2008, p. 154). Much of the literature prior to the early 2000s has been characterized as having "acknowledged and mentioned the principal-agent relationship, but deeper examinations of this relationship as an agency relationship [were] left aside," while more recent research has sought to apply agency theory as a "conceptual framework, heuristic tool, or as an organising concept that aimed to offer insights related to university governance" (Kivistö, 2008, p. 340).

Gomez-Mejia and Balkin (1992) utilized agency theory in their examination of the determinants of faculty pay at universities. In order to test their 12 hypotheses, Gomez-Mejia and Balkin (1992) collected a stratified random sample of 1,100 management professors who were members of the Academy of Management, as 60% of the sample was drawn from doctorate-granting institutions and 40% from non-doctoral granting institutions. A total of 353 surveys were included in their final analysis. The authors examined the relationship between university administrators (principals) and faculty (agents) as it pertained to determining faculty pay. Due to the complexity and level of expertise required for academic work conducted by faculty members, informational asymmetries exist between faculty and administrators (Kivistö, 2007), creating a higher agency cost to monitor faculty behavior and work (Gomez-Mejia & Balkin, 1992). Using hierarchical multiple regression analysis consisting of variables associated with research productivity and teaching performance, the authors found that faculty performance, as indicated by top-tier publications, had the greatest impact on faculty salary. In general, Gomez-Mejia and Balkin (1992) suggested that "agency theory is robust and useful as an explanatory framework for examining monitoring issues or agency problems internal to organizations" (p. 946).

Liefner (2003) conducted a series of qualitative case studies of six institutions across three countries in the late 1990s, applying a modified principal-agent model in studying how resource allocation through various forms of payments affected the behavior of institutional personnel. Operating under the assumption of "uniform human behavior", Liefner (2003) tested two hypotheses: (1) Agents that have been rather inactive before the introduction of performance-based resource allocation will have to work harder; and (2) With performance-based resource allocation agents will tend to avoid projects with high chance of failure, while

departments and individuals will concentrate on activities where success can be expected because they will have to meet a formula's criteria or market demand (pp. 478-479).

Based on data collected through 53 interviews with professors, the author found that the introduction of performance funding resulted in agents working harder, while professors reported the lack of performance funding encouraged risk-taking activities by scholars. Further analysis indicated that professors rated faculty qualifications as being the most important factor in long-term success of universities, with the form of resource allocation and other incentives ranking below student ability/motivation and university culture (Liefner, 2003, p. 485). While Liefner (2003) found that the form of resource allocation was not a factor in long-term success of universities, the author argued that performance funding could "(1) force universities and individuals to pay attention to the needs of governments and taxpayers, (2) help to adjust the organizational structures of universities more quickly to the emerging needs and opportunities, and (3) be used to re-allocate funds to those groups and scholars that have proved to be successful and to reduce the budgets of those who are not performing in an acceptable way" (p. 486).

Gornitzka, Stensaker, Smeby, and De Boer (2004) applied principal-agent theory as a theoretical framework in an analysis of the contractual arrangements between the state and higher education institutions in Finland, Sweden, and Denmark, in an attempt to address the core issue of the tension between effectiveness versus efficiency in higher education. They argued that government-university contracts, increasingly born out of a growing lack of trust, have been shifting from a "sort of unwritten and quite broadly specified gentlemen's agreement on the roles and responsibilities of the state and the higher education institutions" towards a "more formal, written economic agreement that specifies the relationship between the two parties in terms of

tasks, processes, and outcomes" (p. 88). Viewed through the lens of agency theory, the contractual arrangements serve as an attempt to overcome the agency problem of informational asymmetry and goal conflict existing in the government-university relationship (Gornitzka, Stensaker, Smeby, & De Boer, 2004). The presence of multiple principals complicates the agency problem, as there is growing interest in "diversifying the funding of higher education" through external funding sources to overcome the reduction in government-level funding (Gornitzka et al., 2004). The authors' findings indicated that contractual arrangements could not solve the problem of informational asymmetries, as institutional agents retained the capacity to exhibit moral hazard and adverse selection, even within contract arrangements designed to clarify outcome expectations, tasks, and behaviors. However, they concluded that informational asymmetries could be decreased through contractual arrangements that more closely integrated external quality evaluations systems with other regulatory instruments and processes (Gornitzka et al., 2004).

Focusing on the European higher education context, Kivistö (2005) systematically examined the key constructs associated with agency theory and applied each construct to the government-university relationship. Kivistö (2005) addressed issues related to the agency problem, including adverse selection, moral hazard, and informational asymmetries, as well as the several of agency variables (outcome measurability, outcome uncertainty, task programmability, and goal conflict) posited by Eisenhardt (1989). Kivistö (2005) primarily concluded that agency theory could be a useful framework for analyzing the government-university relationship and explaining certain government behaviors, including why governments seek information from institutions prior to making funding decisions (adverse selection); why governments create quality assurance mechanism (moral hazard); and why governments are

increasingly choosing to implement performance-based funding mechanisms (outcome-oriented contracts) as an alternative to behavior-oriented contracts that define input-based funding (goal conflict, moral hazard).

Data Envelopment Analysis

The estimation of production frontiers has been broadly divided into two categories: statistical approaches and non-statistical approaches. The primary differences between these categories include the "assumptions imposed on the specifications of the efficiency frontier, the existence of random error, and the distribution of the inefficiencies and random error" (Paradi, Yang, & Zhu, 2011). Statistical (or econometric) approaches, which include ordinary least squares (OLS) regression, corrected OLS (COLS), and stochastic frontier analysis (SFA), assume a specific form of the production function, allow for the influence of stochastic (random) events beyond a firm's control, and capture measurement error, statistical noise, or random variation in the error term of the linear regression model (Greene, Fried, Lovell, & Schmidt, 2008). In contrast to statistical approaches, non-statistical (or programming) approaches do not impose a specific functional form on the production function a priori, but allow the inputs and outputs in the data to determine, through linear programming methods, the production function (Johnes, 2006). Programming approaches also assume that input and output data do not contain measurement error or noise (Avkiran, 2001).

One of the most utilized non-statistical methods for estimating the production frontier of firms is Data Envelopment Analysis (DEA). DEA was introduced by Charnes, Cooper, and Rhodes (1978) as a non-parametric, mathematical programming-based technique that can be "applied to observational data [that] provides a new way of obtaining empirical estimates of relations -- such as the production functions and/or efficient production possibility surfaces --

that are cornerstones of modern economics" (Cooper et al., 2011). Essential to DEA is the idea of efficiency, also referred to as either Pareto efficiency or Pareto-Koopmans efficiency, which stipulates that a Decision Making Unit (DMU) is efficient if and only if the following inefficiencies do not exist: (1) A DMU is inefficient if it can increase an output without increasing an input or decreasing an output (output orientation); and (2) A DMU is inefficient if it can decrease input without increasing another input or decreasing an output (Avkiran, 2001; Charnes, Cooper, & Rhodes, 1981). Charnes et al.'s (1978) seminal work built on the measure of technical efficiency devised by Farrell (1957) that focused on the proportional change of inputs and outputs. The Farrell input efficiency measure provides an estimation of the level of input that can be proportionally reduced while producing the same output; conversely, the Farrell output efficiency measure is the maximum expansion of outputs for a given set of inputs (Bogetoft & Otto, 2010).

Charnes, Cooper, and Rhodes (1978) proposed DEA as a means for measuring the efficiency of DMUs that could be "obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU be less than or equal to unity" (p. 430). The Charnes, Cooper, and Rhodes model, CCR as it is commonly known, reduces multiple outputs and multiple inputs for each DMU into a "single 'virtual' output and 'virtual' input" (Cooper et al., 2011). To measure DMU efficiency, a ratio is calculated using the virtual output to virtual input for each DMU, which is then compared to the relative efficiency ratios for all other DMUs in the sample. A ratio value of 1.0 indicates technical efficiency, while an efficiency score below 1.0 indicates technical inefficiency. The DMUs demonstrating technical efficiency create a piecewise linear efficiency frontier against which the

DMUs not operating on the efficiency frontier, i.e., demonstrating technical inefficiency, can be measured (Johnes, 2006).

One of the primary assumptions in the CCR model is constant returns to scale (CRS), which harkens back to the proportionality constraints offered by Farrell's efficiency measures. Under CRS, any increase/decrease in inputs will result in a proportional increase/decrease in outputs. An example of CRS within the context of higher education is that doubling inputs (e.g., academic expenditures, full-time faculty) would linearly result in doubling outputs (such as graduation rates) (Archibald & Feldman, 2008). In reality, many situations exist where the underlying distribution of the data cannot be assumed to conform to the CRS assumption. To account for instances where the CRS assumption does not hold, Banker, Charnes, and Cooper (1984) developed the BCC model that relaxed the CRS assumption. The BCC model introduced the concept of variable returns to scale (VRS) that allows for increasing returns to scale (IRS) and decreasing returns to scale (DRS) resulting from disproportionate rise in outputs in comparison with inputs assumed under CRS (Thanassoulis, Portela, & Despic, 2008). The efficiency frontier created under the BCC model (VRS assumption) will more closely envelop the data set than an efficiency frontier under the CCR model (CRS assumption), as estimated efficiency results of the BCC model are typically higher than those estimated under the CCR model (Fried, Lovell, & Schmidt, 2008).

Relaxing the CRS assumption in the BCC model allows researchers to calculate both VRS efficiency and CRS efficiency within a single DEA model. When combined, these measures provide the means to determine another measure of efficiency: scale efficiency. Scale efficiency specifies how close the DMU is to operating at its optimal scale size, as scale efficiency is a ratio calculated by dividing the DMU's CRS efficiency by its VRS efficiency

(Thanassoulis et al., 2008). Higher scale efficiency ratios indicate DMUs that are operating closer to optimal scale size. From the perspective of the DMU, the calculation of scale efficiency is "appealing because it provides a measure of what could be gained by adjusting the size of the firm" (Bogetoft & Otto, 2010).

Benchmarking

The current scrutiny higher education institutions are receiving for their levels of productivity and efficiency has stemmed, in part, from stakeholders making value judgments regarding colleges and universities. Policymakers seek to determine the best way to allocate state funds to institutions, a primary impetus for renewed interest in performance-based funding, and parents and students want to know where they will get the "most bang for their buck." As an analytical technique, DEA provides a means for "benchmarking" colleges and universities against one another to determine who is and is not functioning at an efficient level.

In the DEA framework, benchmarking stems from the measurement of institutional efficiency as the "relative ability of each DMU in producing outputs, where the term relative means that each organization is compared with any other homogeneous unit" (Agasisti & Dal Bianco, 2009, p. 486). From a performance management perspective, DEA-based results benefit institutions by identifying peer DMUs from which inefficient institutions can learn and determine ways to close the gap between themselves and comparable DMUs operating on the efficiency frontier (Archibald & Feldman, 2008). According to Bogetoft and Otto (2010), benchmarking through DEA is important to DMUs because of the perspective provided: "The point is, however, that it is not sufficient for a firm to improve compared to itself. The firm must also improve relative to others, and they have also benefited from general technological progress. Thus, the only way to improve is to catch up to the best, i.e., to get closer to the frontier" (p. 43).

Bootstrap Method

One of the core shortcomings of the base DEA methodology is its inability to test the statistical significance of estimated efficiency values, given that it is a non-parametric, non-statistical technique. Compounding this issue is that DEA has been deemed a deterministic technique in that a DMU's distance from the efficiency frontier is entirely accounted for by DMU inefficiency, with no consideration of measurement error, noise in the data, or stochastic factors beyond the control of the DMU (Greene et al., 2008). Although being labeled deterministic carries the implication that DEA models lack "statistical underpinnings," Simar and Wilson (2000) argued that relative efficiency estimates derived from DEA models exhibit a level of uncertainty attributable to sampling variation. In an effort to overcome these perceived deficiencies, Simar and Wilson (1998, 1999, 2000) developed a bootstrapping technique designed to account for the sensitivity of estimated efficiency scores to sampling variations by correcting for bias introduced by the DEA model and calculating confidence intervals for the bootstrapped estimates.

Originally introduced by Efron (1979), Simar and Wilson (1998) characterized bootstrapping as "repeatedly simulating the data-generating process (DGP), usually through resampling, and applying the original estimator to each simulated sample so that resulting estimates mimic the sampling distribution of the original estimator" (p. 49). In DEA, the underlying DGP is unknown. DEA measures efficiency in relative, not absolute, terms, as the efficiency frontier, determined in DEA through the use of a finite sample of observed data, serves as an estimation of a true frontier that is unobserved (Simar & Wilson, 2000). The basic concept of the bootstrap method is that if the DGP produced through the bootstrap process is a reasonable estimator of the original DGP, then the sampling distributions of the bootstrapped

values will approximate the original unknown DGP sampling distributions, allowing for statistical significance testing to occur (Simar & Wilson, 2000). Once a set of bootstrap values has been calculated, the empirical distribution of this set can approximate the unknown sampling distribution of the underlying DGP, allowing for statistical inferences and bias correction to occur (Kneip, Simar, & Wilson, 2011).

In their originating article to the technique, Simar and Wilson (1998) examined the sensitivity of efficiency scores of 19 electric utilities from cross-sectional data collected in 1978 in relation to the sampling variations of the DEA-estimated frontier. After initially calculating DEA efficiency estimates by using one output and three inputs, Simar and Wilson used the bootstrap method to calculate bias-corrected efficiency estimates based on 1,000 replications. The authors calculated separate confidence intervals from mean-centered and median-centered bias-corrected estimates, as the 95% confidence intervals were very similar across both calculations. Overall, Simar and Wilson found that DEA efficiency measures exhibited sensitivity to sampling variation, as the authors encouraged caution to be exercised when interpreting DMU efficiency based on original, biased DEA efficiency scores (Simar & Wilson, 1998). Across the 19 DMUs in the sample, estimated bias in original efficiency scores ranged from 0.0111 to 0.0742. Given that efficiency estimates are ratios bounded at 0 and 1, the DMU with the largest amount of bias went from being deemed technically efficient, based on a value of 1.0 in the original efficiency estimates, to exhibiting technical inefficiency with a bias-corrected efficiency estimate of 0.9258.

Results also indicated that comparisons between firms can be impacted when accounting for bias in efficiency estimates. For example, under the original DEA estimates, DMU 1 in the sample was 0.1308 lower than DMU 2 (0.8692 versus 1.000, respectively). However, when

correcting for bias, the gap between DMU 1 and DMU 2 was reduced to 0.0788 (0.8519 versus 0.9307, respectively). Even though the authors characterized the differences between the two DMUs as seeming substantial, the 95% confidence intervals calculated on the bias-corrected efficiency estimates overlapped between the two DMUs (Simar & Wilson, 1998). This overlap indicated a non-statistically significant difference between the two firms, a finding that is not possible under the base DEA method and requires the bootstrap technique in order to approximate the underlying, unknown DGP.

Simar and Wilson (2007) extended their bootstrap procedure to a two-stage, semi-parametric model in which first-stage DEA efficiency estimates were regressed on exogenous variables using a second-stage truncated regression technique. In a review of 48 published studies that utilized a two-stage approach, Simar and Wilson reported the majority used a censored (Tobit) model in the second-stage regression, while others used various forms of an ordinary least square (OLS) regression model in stage two of the procedure. Simar and Wilson (2007) argued that none of these studies "described the underlying DGP," causing "some doubt about what is being estimated in the two-stage approaches" (p. 32). Another point of concern issued by Simar and Wilson (2007) was that the two-stage techniques used in these studies were invalid due to estimated efficiencies exhibiting serial correlation. This correlation is due to the relative nature of finite samples in DEA models, as changes in the DMUs residing on the estimated frontier will likely lead to adjustments in the estimated efficiencies for other DMUs in the sample (Simar & Wilson, 2007). Correlation also exists between the error terms and environmental variables, which can cause issues related to estimating technical efficiency and making inferences regarding parameters in the two-stage regression procedure (Simar & Wilson, 2007). According to Lee (2011), "It is well documented in the DEA literature that the efficiency

scores obtained in the first stage are correlated with the explanatory variables used in the second stage, which makes the second-stage estimates inconsistent and biased" (p. 199).

Simar and Wilson (2007) initially conducted a series of Monte Carlo experiments in which they applied both their single-bootstrap (Algorithm #1) and double-bootstrap (Algorithm #2) algorithms. The primary difference between the two stems from the double-bootstrap algorithm using a parametric bootstrap procedure during the first-stage of the two-step technique to provide bias-corrected estimates of efficiency that were incorporated in the second-stage regression model (Simar & Wilson, 2007). Across the various experiments, the two bootstrap algorithms consistently outperformed either Tobit regression or Truncated regression (under conventional inferences) as measured by the proportion of the 1,000 Monte Carlo trials in which the estimated confidence intervals covered the parameter values of β_1, β_2, and ε. Simar and Wilson (2007) then applied their single- and double-bootstrap techniques to a random sample of 322 banks, plus the full data set of 6955 banks (after data cleaning) from the United States, as they included three inputs and four outputs in their model of cross-sectional data from 2002. The authors regressed DEA efficiency estimates, generated in stage one of the procedure, on the covariates in stage two, calculating 95% confidence intervals under conventional methods and Algorithm #1, while also conducting the double-bootstrap (Algorithm #2) in a separate procedure. Results indicated that Algorithm #2, which created bias-corrected efficiency estimates, produced parameter estimates and estimated confidence intervals that were different from either the conventional or Algorithm #1 methods, while confidence intervals from Algorithm #1 were different from conventional methods. In both the sample (322 banks) and full (6955 banks) data sets, there were numerous instances where the confidence intervals in the bootstrap algorithms did not overlap the estimated parameters (Simar & Wilson, 2007). Simar

and Wilson attributed these findings, in part, to low convergence rates inherited by the second-stage regression from the DEA estimator, as the convergence rate can be specified as $n^{-2/(p+q+1)}$, where n is the number of observations in the sample. For example, based on the sample of 6955 banks, the convergence rate ($6955^{-2/9} \approx 51^{-1/2}$) was the equivalent of making inferences on approximately 51 observations in a typical parametric, truncated regression procedure, which limits the inference-making ability of the researcher (Simar & Wilson, 2007). Simar and Wilson also noted that the true DGP in a non-parametric analysis is unknown, which can be an indication that the true DGP, as estimated by the bootstrap procedure, is different from the one assumed by the parametric model used in this study.

Malmquist Index

In addition to not allowing for statistical inferences, the base DEA technique is also unable to "distinguish between changes in relative efficiency brought about by movements towards or away from the efficiency frontier in a given year and shifts in this frontier over time" (Flegg, Allen, Field, & Thurlow, 2004, p. 231). To overcome this feature of DEA, the Malmquist index (Caves, Christensen, & Diewert, 1982) was generalized to contexts that do not have observed prices and where assumptions related to firms being revenue maximizers or cost minimizers did not hold. Malmquist indices are constructed using distance functions, which provide a measure of how far inefficient DMUs reside away from the efficiency frontier (Färe, Grosskopf, Lindgren, & Roos, 1994). The output distance function indicates the level of technical efficiency demonstrated by a DMU due to producing less output than is possible based on a set of given inputs; the input distance function suggests the level of "economic" inefficiency demonstrated by a DMU due to excessive inputs beyond what is needed to produce the observed outputs (Greene et al., 2008). Färe et al. (1994) adopted an output-oriented model in their

analysis of productivity change in the Swedish hospital sector, as output-oriented models are utilized when the objective is to maximize outputs while not increasing the number of inputs above the level observed (Parteka & Wolszczak-Derlacz, 2013).

In order to account for change across time periods, the Malmquist index introduces an initial time period *t* with technology T_c that serves as a benchmark against which subsequent time periods *t+1* can be compared (Fried et al., 2008). In a basic example of a model with one input and one output with two time periods *t* and *t+1*, productivity change is determined by first calculating the ratio of output to input for each time period, and then taking the ratio of these ratios (Färe, Grosskopf, & Margaritis, 2011). Under the constant returns to scale assumption and an output orientation, the Malmquist index provides a measure of total factor productivity (TFP), as a value greater than one represents positive TFP growth, while a value less than one indicates TFP decline from period t to period t+1 (Parteka & Wolszczak-Derlacz, 2013).

One of the benefits to utilizing Malmquist productivity indices is that they can be decomposed into technical efficiency change and technological change components, which are the two primary components associated with TFP progress or regress (Färe et al., 2011; Parteka & Wolszczak-Derlacz, 2013). Changes in technical efficiency are associated with a DMU getting closer to or moving away from the efficiency frontier, while technological change represents a general shift in the production frontier as a whole. Changes in technical efficiency, also known as the "catching-up" effect, can further be decomposed into changes in scale efficiency and pure efficiency to more closely identify main sources of change (Parteka & Wolszczak-Derlacz, 2013; Worthington & Lee, 2008).

DEA Studies of Higher Education Institutions

Analyzing the efficiency of higher education institutions is challenging from a variety of perspectives. Johnes (2006, 2008) noted that universities are typically non-profit making, do not consist of output and input prices, and produce multiple outputs from multiple inputs. To overcome these constraints, DEA is an appropriate method of measuring efficiency of HEIs, given that distance function approaches require neither input/output prices nor assumptions regarding the cost minimization or profit/revenue maximization behavior of the DMUs (Coelli, Rao, O'Donnell, & Battese, 2005). Wolszczak-Derlacz and Parteka (2011) also argued that DEA is appropriate in analyzing efficiency of universities from the standpoint that DEA "allows the researcher to capture multiple inputs and multiple outputs at the same time, focusing on the non-parametric treatment of the efficiency frontier" (p. 890).

While widespread in different industries, the use of non-parametric techniques to estimate efficiency levels of DMUs has had relatively limited application in the higher education sector (Wolszczak-Derlacz & Parteka, 2011). According to a web site dedicated to maintaining a searchable bibliography of DEA-related publications in scientific journals (http://www.deabib.org, as of December 2, 2011), 4,055 DEA-based journal articles were published from 1950 - 2010. A search of the database performed on July 9, 2014 with Version 0.8.1 returned 224 unduplicated citations using search terms "university", "universities", "schools", and "higher education", indicating that approximately 5.5% of published journal articles apply DEA to the higher education sector. A similar search of the database by Wolszczak-Derlacz and Parteka (2011) of publications ranging from 1950 to 2007 showed that 3.5% of the studies pertained to higher education issues, as the proportional increase seems to indicate growth in the application of DEA methods to higher education research. Overall, this

body of literature is primarily international in nature, with relatively few DEA studies published that analyze efficiency and productivity of higher education institutions in the United States (Sav, 2012).

Due to the non-parametric, deterministic nature of DEA, the selection of inputs and outputs to include in any model is a vital step in the implementation of a DEA-based procedure. One of the problems surrounding this issue is the lack of definitive research related to selecting inputs and outputs for inclusion in a DEA model within the education sector (Avkiran, 2001). A search through recent literature failed to provide specific guidelines related to initial input/output selection, as the focus of DEA is typically not on the inputs and outputs included in a model (Worthington & Lee, 2008). However, as seen in Table 5, a survey of recent publications indicates there is a certain level of consistency in the selection of input and output variables in DEA-based research of higher education.

Most of these studies included outputs that serve as proxies of teaching and research quality, while service is rarely utilized as an output in DEA studies of higher education. Primary examples of outputs include the number of degrees awarded/graduates (teaching), amount of grants awarded (research), and number of publications (research). Inputs exhibit greater variance, although the number of students, number of faculty/academic staff/administrative staff, expenditures (academic, capital, auxiliary), and measures of incoming student quality are the primary types of inputs used across these studies.

While many DEA-based applications in other industries rely on input-oriented models, the majority of higher education DEA-based research have used output-oriented models (Worthington & Lee, 2008). An output orientation has typically been used in this sector given that colleges and universities have limited ability to increase the quantity or quality of the inputs,

i.e., students and revenues, in a short period of time (Parteka & Wolszczak-Derlacz, 2013). This emphasis on increasing efficiency through output maximization within the confines of existing input levels mirrors the emphasis of policymakers and other stakeholders who are pressuring higher education institutions to become both more productive and more efficient within given resource constraints.

Research Studies

Johnes (2006) used DEA methodology to study the efficiency of 100 higher education institutions spanning three categories in England during the 2000-2001 academic year. Using an output-oriented approach, Johnes (2006) conducted a single-stage DEA procedure that included three outputs (weighted total number of first degrees awarded, total number of higher degrees awarded, and value of recurrent grants for research) and six inputs (undergraduate quality, number of FTE postgraduate students, number of full-time academic staff, capital expenditures, library/information expenditures, and administrative expenditures). Following the initial DEA with the full set of variables, Johnes conducted the Pastor's test (Pastor, Ruiz, & Sirvent, 2002) to determine which variables were significant, as the Pastor's test indicated the staff and library/information expenditures variables could be removed. Johnes applied the full and reduced models on each subgroup, finding that the sample of English universities demonstrated very high general efficiency. The average efficiency estimates ranged from 93% to 95% across the two models applied to the three subgroups, as the number of institutions found to be efficient ranged from 51 to 61 across the models and subgroups. Statistical tests (F-test and Kruskall-Wallis test) did not indicate statistically significant differences in the mean efficiency estimates (technical efficiency or scale efficiency) across groups. In order to assess the differences in estimated efficiency scores across individual institutions, Johnes (2006) used bootstrapping procedures

(Simar & Wilson, 1998, 2000, 2011) to estimate 95% confidence intervals, finding "no overlap between the 22 lower performing HEIs and those HEIs which have the maximum efficiency score" (p. 280), suggesting that DEA "can discriminate between the worst- and best-performing HEIs" (p. 286).

In mirroring components of the *US News and World Report* ranking system, Archibald and Feldman (2008) conducted a cross-sectional study of 187 American "national" institutions in which the output variable was the institution's 6-year graduation rate in 2003-2004. The four input variables in the study were the percent students enrolled who were in the top 10% of their high school class, the 25th percentile SAT score, the percentage of full-time faculty, and the cost per undergraduate. One of the unique aspects of this study was the comparison of methodologies, as the authors analyzed the same data using both regression and DEA techniques. The DEA analysis generated a mean technical efficiency score of 0.896 for the 187 institutions in the sample. A quadrant analysis was conducted, in which institutions' residuals were plotted along the x axis while their technical efficiency scores were plotted along the y axis, with the middle of the residuals set at 0 and the technical efficiency dividing line set at the mean value of 0.9. When comparing the residuals with the technical efficiency scores, the authors found a correlation of 0.6708. The two techniques agreed in 79% of the cases on the placement of institutions on the plot with quadrants, with 79 institutions being rated "above-average" on both measures, and 69 institutions being rated "below-average" on both measures. Archibald and Feldman (2008) argued that the 21% of discordant results between the two methods highlights the advantages of using a production frontier approach, given that the 12 institutions that exhibited an above-average residual with below-average technical efficiency score might be "satisfied" when they actually were performing below the best practices of comparable institutions in their level of

estimated efficiency. Similarly, the 27 institutions that demonstrated above-average technical efficiency scores, but had below-average residuals, would be viewed as inferior under regression-based techniques, but are actually "...on or very close to the production frontier. Given their inputs, they are doing very well" (Archibald & Feldman, 2008). In summarizing their findings, Archibald and Feldman (2008) provided a detailed list of why they prefer DEA over parametric, regression-based techniques (p. 93):

1. While the two techniques often provide similar results, they don't always.
2. Production frontier analysis is more intuitively appealing because it compares institutions to best practice, not average practice.
3. DEA is less restrictive because it does not impose a functional form on the production surface.
4. DEA is based on comparisons width institutions in the neighborhood of the institution being rated and not on average based on the entire data set.
5. None of its judgments are based on extrapolations outside of the observed data.
6. Production frontier analysis provides several useful measures, like technical efficiency and input slacks that tell an institution how it differs from its close neighbors that are efficient.
7. DEA creates peers for every inefficient institution so that it is easy to identify the institutions with potentially superior practices.

Flegg et al. (2004) studied efficiency of 45 HEIs in the United Kingdom from 1980-81 to 1992-93, a period defined by the combined shifts related to public funding and student:staff ratios. Flegg et al. (2004) incorporated three output (income from research and consultancy, number of undergraduate degrees awarded, and number of postgraduate degrees awarded) and

four input variables (number of staff, undergraduate students, postgraduate students, and aggregate departmental expenditure) in their DEA model that was based on an output orientation. Initial results of estimating HEI technical efficiency showed a trend toward homogeneity of HEIs based on unweighted arithmetic mean efficiency estimates over time, as the standard deviation of technical efficiency scores dropped from 0.144 in 1980/81 to 0.077 in 1992/93, and the minimum technical efficiency score estimated in the sample rose from 0.488 to 0.742 on a 0 to 1 scale (Flegg et al., 2004). Accounting for student population density at individual HEIs, the authors also calculated weighted arithmetic mean and weighted geometric mean technical efficiency scores, which demonstrated a similar pattern across the years considered in the study. A decomposition of technical efficiency into component parts (pure technical efficiency, congestion efficiency, and scale efficiency) indicated that the weighted geometric means of the 45 institutions under study were relatively stable over time. Flegg et al. (2004) also calculated Malmquist total factor productivity (TFP) index scores to evaluate whether increased efficiency scores were due to improve performance in terms of technical efficiency of the institution, simply a change in technology relative to an overall shift in the efficiency frontier. The results showed that TFP increased 51.5%, with the technology frontier increasing 39.1% and technical efficiency increasing 8.8% during the 13 years of the study. These findings were interpreted as indicating that most of the increase in TFP can be attributed to an "outward shift in the efficiency front rather than by enhanced technical efficiency" that would signal improvement in HEIs that were becoming more efficient (Flegg et al., 2004).

Johnes (2008) conducted a study of 112 higher education institutions in England in which efficiency and productivity were estimated in order to compare HEI subgroups across the UK. Using data from 1996-97 to 2004-05, Johnes' DEA model included three output measures

(undergraduate degrees/qualifications awarded, postgraduate degrees/qualifications awarded, and research income) and five inputs (full-time academic staff, administrative expenditures, academic expenditures, FTE undergraduate enrollment, and FTE postgraduate enrollment). Johnes initially analyzed all HEIs in the sample, secondarily segmenting by institution type (pre-1992, post-1992, and SCOP) and conducting the analysis, finding that estimated efficiency scores were typically higher when analyzing data at the subgroup level as opposed to all HEIs being analyzed together. Overall technical efficiency was high, with the mean score ranging from 88 to 95 percent across the various models. Johnes (2008) applied a Kruskal-Wallis test to two sets of results: overall, pure, and scale efficiency scores, and indexes consisting of technical efficiency change, technology change, and Malmquist total factor productivity change. Results indicated the subgroups differed at a statistically significant level ($p < 0.05$) in overall technical and scale efficiency, and in technology change distributions. Johnes (2008) also found that annual productivity increases were attributable to changes in technology as opposed to increases in institutional technical efficiency.

Worthington and Lee (2008) studied 35 Australian universities from 1998-2003, estimating productivity growth through an output-oriented DEA model that included six outputs (undergraduate completions, postgraduate completions, PhD completions, national competitive grants, industry and other grants, and publications) and five inputs (FTE academic staff, FTE non-academic staff, non-labour input expenditure, actual undergraduate student load, and actual postgraduate student load). In their analysis of the full sample of institutions, Worthington and Lee (2008) found a mean annual productivity growth of 3.3%, as decomposition of Malmquist index scores indicated most of this improvement was due to technological progress as opposed to gains in technical efficiency. When institutions were analyzed by university type (research-only

and teaching-only), the research-only institutions averaged a 6.3% increase in productivity growth, while the teaching-only institutions' productivity increased by 2.9% annually from 1998-2003. Research gains in productivity were primarily associated with increased technical efficiency rather than technological improvement, while increased productivity in teaching-only institutions was primarily due to technological improvements rather than technical efficiency (Worthington & Lee, 2008).

Agasisti and Johnes (2009) utilized a three-step process to study the estimated efficiency levels of 57 Italian and 127 English HEIs in a cross-country analysis of data spanning academic years from 2001-02 to 2004-05. Agasisti and Johnes (2009) used an output-oriented framework that included four inputs (number of students, amount of financial resources/incomes, number of PhD students, and number of academic staff) and three outputs (bachelor graduates, masters graduates, and amount of external grants and contracts for research). In step one, the authors analyzed English and Italian institutions separately, finding that the mean efficiency score within countries was in excess of 0.80 in all three measures of efficiency (BCC, CCR, and Scale). These results did not hold for Italian institutions when data were pooled across the 184 HEIs in the dataset. While all of the English institutions' mean efficiency scores remained above 0.80, the mean efficiency scores for Italian institutions ranged from 0.64 (CCR) to 0.84 (Scale). These results highlight the "relative" nature of DEA-based research. A closer examination of the returns to scale data revealed that 61% of English institutions and 84% of Italian institutions in the study exhibited decreasing returns to scale, an indicator that these institutions might benefit from "diminishing the scale of their operations" (Agasisti & Johnes, 2009, p. 70). Steps two and three involved Agasisti and Johnes conducting a dynamic analysis across academic periods ranging from 2001-02 to 2004-05, initially calculating Malmquist indices on the pooled sample prior to

separating the institutions by country. Italian institutions experienced overall growth in performance with a Malmquist index score of 1.094 for the whole period, primarily because of their change in technical efficiency of 1.775. English institutions demonstrated relatively stable performance on both technical efficiency and Malmquist index measures. In general, positive changes in estimated efficiency for individual English universities was due to improvements in technology (frontier shifts), while improvements in Italian universities were attributed to institutions improving their technical efficiency as opposed to frontier shifts across the sample of institutions.

In their analysis of teaching reforms in Italy stemming from the Bologna Process introduced in 1999, Agasisti and Dal Bianco (2009) analyzed the efficiency performance of 74 universities (60 public and 14 private) spanning the 1998-99 to 2003-2004 academic years. Their initial output-oriented model included two outputs (graduates and graduates in four or five year courses) and six inputs (total enrollments, first-year students scoring high (9/10) on secondary school exam, total number of regular students, total number of students, total staff, and facilities/structures). Agasisti and Dal Bianco (2009) initially applied the DEA model to all institutions in the dataset, utilizing the Pastor's (Pastor et al., 2002) test and Spearman correlation tests to assess the variables included in the model, which resulted in the removal of total enrollments and total number of regular students being dropped from the model. Results from the revised model being applied to the full dataset indicated a sharp one-year decline in pure efficiency and scale efficiency in 2002-03, the year after the Bologna teaching reforms were enacted in 2001-02. Agasisti and Dal Bianco (2009) interpreted this finding as stemming from a disproportionate increase in enrollment, due to teaching reforms, as compared to the outputs of graduates during that same year. In 2003-04, scale efficiency and pure efficiency rebounded to

similar levels of 2001-02. The authors also conducted separate analyses for public and private institutions, finding that private institutions were more efficient than their public counterparts (Agasisti & Dal Bianco, 2009).

Agasisti, Dal Bianco, Landoni, Sala, and Salerno (2011) employed a two-step DEA methodology in their analysis of the research efficiency of 75 university departments at institutions located in the Lombardy Region of Italy. The authors incorporated three inputs (laboratories, highly-qualified human resources, and administrative personnel) and five outputs (regional/national revenues, international revenues, order-based revenues, yearly number of publications, and number of doctorates in cooperation with external funding bodies) in their analysis using data from 2004-2007. A first-step analysis of university departments' research efficiency using data from 2007 indicated CRS efficiency to be 0.75 and VRS efficiency to be 0.79, as the mean scale efficiency score was 0.94. Even with relatively high mean efficiency scores, standard deviations for the efficiency scores (CRS = 0.24 and VRS = 0.22) indicate differentiation exists within the departments. A second step involved the calculation of Malmquist index scores for data from 2004 to 2007, as the mean Malmquist index of 1.06 across the four years indicated relatively minimal improvement in productivity. However, when the Malmquist index was decomposed into technical efficiency and technological efficiency scores, the departments in the study collectively exhibited strong technical efficiency change (1.67) coupled with a worsening technology frontier (0.65). Having defined technology as the "bundle of policies that should help in improving research efficiency" (p. 280), Agasisti, et al., (2011) interpreted the low technology frontier value as indicating an "opportunity for a regional government to be involved in this sector", and, alternatively, as reflecting that the "policies adopted for boosting research productivity were not adequately designed" (p. 281). In the final

step of their analysis, Agasisti, et al., (2011) evaluated the possible impact of a variety of external factors on research efficiency by using the Kruskal-Wallis test for each factor, finding no statistically significant influence of Metropolitan location, subject mix, university effects, tenured staff proportion, or departments' age on the research efficiency of the university departments under study.

Wolszczak-Derlacz and Parteka (2011) conducted a multi-national analysis of 259 HEIs from seven European countries with the purpose of "not only evaluat(ing) the relative technical efficiency of European higher education institutions in a comparative setting, but also to reveal external determinants of their performance" (p. 888). Wolszczak-Derlacz and Parteka (2011) utilized the two-stage DEA analysis approach developed by Simar and Wilson (2007) that involves an initial estimation of DEA scores that are then regressed on exogenous variables in a stage two bootstrapped truncated regression. Wolszczak-Derlacz and Parteka (2011) used an output-oriented CRS efficiency model that incorporated two outputs (number of graduations and number of scientific publications) and three inputs (total academic staff, number of students, and total revenues). The first stage DEA produced a mean estimated efficiency score of 1.55 for the full sample, which is interpreted as meaning the institutions collectively would have to improve their output by as much as 55% to reach efficiency. In the full sample, only 5% of HEIs were 100% efficient as determined by an estimated efficiency score of 1.0. Using the bootstrapped method, Wolszczak-Derlacz and Parteka (2011) calculated unbiased efficiency estimates that showed a reduction in the mean efficiency levels of countries in the sample when compared to the original biased estimates in step one. In step two of the analysis, Wolszczak-Derlacz and Parteka (2011) used a parametric model in order to regress the estimated efficiency scores generated in step one on potential environmental variables that could have an impact on DMU

efficiency levels. Five of the six exogenous variables included in the truncated regression were highly statistically significant, as regional Gross Domestic Product (GDP) per capita did not significantly impact estimated efficiency scores when accounting for the other variables in the regression model. Three of the significant variables (number of faculty, existence of medical/pharmacy faculty, and ratio of women to total faculty) promoted an increase in estimated efficiency, while younger institutions and a higher percentage of revenues from core funding were negatively associated with HEI technical efficiency. A variety of robustness checks, including the comparison of restricted DEA models (3 inputs/2 outputs versus 2 inputs/2 outputs), the use of a double bootstrap procedure, and using alternative truncation points, supported the original findings of the two-stage DEA procedure.

Lee (2011) implemented Simar and Wilson's (2007) DEA bootstrap technique to conduct a two-stage, input-oriented variable returns-to-scale (VRS) DEA model in estimating efficiency scores for 37 universities in Australia using data from 2006-2009. The stage one DEA model included two inputs (FTE staff and capital expenditures) and five outputs (national competitive grants, industry grants, other public sector grants, research publications, and number of 'Master's' and 'Doctorate students). Results from stage one indicated that 20 universities were technically efficient under VRS, while 14 were considered scale efficient, which is an indicator of "ideal scale of operations" (Lee, 2011). In stage two, Lee (2011) conducted a truncated regression analysis using bootstrapped bias-corrected efficiency scores generated from stage one, regressing these estimates on four exogenous variables: student load factor, university location (city or non-city), proportion of Associate Professors and Professors to total academic staff, and the Institutional Grants Scheme. All four exogenous variables were determined to be statistically significant in the truncated regression model, as student load negatively contributed to university

efficiency, while the other three variables were positively, significantly associated with the bootstrap estimated efficiency scores (Lee, 2011).

Sav (2012), in one of the few published studies that has applied DEA methodology with panel data to U.S. institutions of higher education, studied 133 research and doctoral universities to estimate DEA efficiency scores and Malmquist total factor productivity scores for academic years 2005-2009. Sav (2012) adopted an output-oriented model that included full academic year of credit-hour production as the lone output, stating the measure "is consistent with the subsidy model under which public universities receive state support revenues in return for credit hour production, not conferred degrees" (p. 20). Sav modeled credit-hour production against three labor inputs (teaching and research faculty, administrative faculty, and academic support) and two capital inputs (expenditures on capital equipment and auxiliary equipment). All data were collected from IPEDS. Sav (2012) found that universities exhibited decreases in CRS (3.5%), VRS (4.5%) and Scale efficiency (0.8%) scores from 2005-06 to 2008-09. Additionally, the percentage of universities deemed efficient (estimated efficiency score of one) dropped from 27% to 20% under CRS and from 42% to 33% under VRS for the time period under study. Calculation of Malmquist TFP change scores resulted in a mean index score of 0.987, indicating a "slight regress in average university productivity over the four academic years," which was primarily attributed to a shift in the production frontier (technology) as opposed to gains in technical efficiency of the institutions (pp. 23-24).

Parteka and Wolszczak-Derlacz (2013) studied the efficiency of 266 public higher education institutions from seven countries in Europe, including Austria, Finland, Germany, Italy, Poland, Switzerland, and the United Kingdom, across the 2001-2005 academic years. The study sought to address two limitations in the extant literature: "(i) little is known about

productivity changes across universities from several countries analyzed within a common methodological framework, and (ii) methodological issues concerning the significance of the results obtained with Malmquist indices have not been appropriately addressed" (Parteka & Wolszczak-Derlacz, 2013). The authors applied Simar and Wilson's (2007) bootstrap DEA technique in order to "obtain bias-corrected estimates of Malmquist indices (and their components) and their confidence intervals" (Parteka & Wolszczak-Derlacz, 2013). The output-oriented model assumed constant returns to scale in order to calculate the Malmquist indices and components, and included two outputs (number of publications and number of graduates) and three inputs (number of students, total academic staff, and total revenues). After estimating the Malmquist indices, Parteka and Wolszczak-Derlacz (2013) performed the bootstrap method with 2000 replications (B = 2,000) in order to compare the mean square errors (MSEs) of the original and bootstrapped estimates. Results showed that the bias-corrected (bootstrapped) estimates of Malmquist indices increased the MSE in comparison to the original (non-bootstrapped) estimates, a finding similar to Simar and Wilson (1999) and defined as plausible by Efron & Tibshirani (1994). As such, the authors utilized original estimates in additional analyses, except for using the bias-corrected, bootstrapped estimates to calculate confidence intervals and determine statistical significance. Across the full dataset, 90% (963 of 1,064) of the annual estimates of total factor productivity growth were "statistically different from unity (at a standard 5% level of significance) so the majority of HEIs registered statistically significant changes in productivity" (Parteka & Wolszczak-Derlacz, 2013). Institutions also annually exhibited a 4.5% average increase in productivity, due primarily to changes in technical efficiency more so than technology improvements. At an institutional level, Parteka and Wolszczak-Derlacz (2013)

found that 28 of the 266 European institutions in the sample demonstrated statistically significant growth in productivity for each of the years in the study.

Chapter Summary

This chapter has provided a review of the literature associated with performance-funding policies in higher education, agency theory, and data envelopment analysis. Following a review of challenges facing Master's institutions and an overview of trends in higher education funding, the third section consisted of a review of performance-funding policy in higher education in the United States, tracing the progression of performance funding from its inception in Tennessee in 1979 to the current movement of what has been deemed Performance Funding 2.0 programs. Section two detailed the literature associated agency theory. The agency theory section included the key constructs across all iterations of agency theory, including the agency problem, informational asymmetries, goal conflicts, moral hazard, and adverse selection, while also detailing differences in how agency theory has been applied across academic disciplines and paradigms, primarily economics and political science. Agency theory will serve as the conceptual framework for examining the existing performance-funding policy in Arkansas as a contractual relationship between the state (principal) and institutions of higher education (agents). The final section of this chapter detailed data envelopment analysis (DEA) and much of the research that has applied DEA in higher education. As the analytical technique being used in this study, DEA provides a means for estimating the efficiency of four-year public institutions in Arkansas in comparison to similar institutions nationally. The utilization of the DEA technique provides a method that can be used to overcome a gap in the Arkansas performance funding model, which currently does not address institutional efficiency within its framework. The

following chapter will detail the methodology for this study that will be used to answer the research questions posed in chapter 1.

CHAPTER III

METHODOLOGY

The purpose of this study was to examine the institutional efficiency of four-year public universities in Arkansas with the Carnegie classification of Master's Colleges and Universities in achieving productivity outcomes specified in the state's newly implemented performance-funding program. The Arkansas performance-funding program includes three levels of performance measures for four-year institutions: mandatory (bachelor credentials, total credentials, STEM credentials, and progression), optional (course completion rate, high demand credentials, minority student credentials, non-traditional student credentials, remedial student credentials, regional economic needs programs credentials, transfer student credentials, expenditure of federal awards, patents, and new company startups), and compensatory (percentage of undergraduate students receiving Pell grants) (ADHE, 2011). As constructed, the measures included in Arkansas's performance funding program do not directly address the issue of efficiency, even though efficiency is specifically referenced within the legislation: "An act to promote accountability and efficiency at state-supported institutions of higher education" (Arkansas Performance Funding Act of 2011). This chapter explains the research design used to address this gap in the performance-funding program related to estimating the efficiency of public four-year institutions in Arkansas. This research was deemed exempt for review and approval by the Institutional Review Board at the University of Arkansas (see Appendix I).

Sample

The performance-funding program in Arkansas provided the policy environment for this study, and as such, four-year public universities in Arkansas served as the initial population from which a sample of institutions were examined. While there are a total of 11 four-year public

institutions in the state, including the University of Arkansas for Medical Sciences, the sample considered in this study included the six institutions with Carnegie classifications of "Master's Colleges and Universities." The Master's-level institutions in Arkansas in this study included one smaller program (University of Arkansas at Monticello), two medium programs (Henderson State University, Southern Arkansas University), and three larger programs (Arkansas State University, Arkansas Tech University, and University of Central Arkansas) (Retrieved from http://nces.ed.gov/ipeds/datacenter/).

The national sample used in this study consisted of 270 four-year public institutions classified as Master's Colleges and Universities that were separated into the three sub-categories: 171 in larger programs, 61 in medium programs, and 38 in smaller programs. Master's Colleges and Universities comprise more than 47% (270 of 571) of all four-year public institutions in the United States, while awarding 36% of all bachelor degrees granted in the U.S. by four-year public institutions of all classifications (Retrieved from http://nces.ed.gov/ipeds/datacenter/). Based on descriptive data of undergraduate populations included in Table 5, the Master's-level institutions in Arkansas exhibited a number of differences when compared with national averages of four-year public institutions in each Carnegie category. Overall, the Arkansas institutions were relatively similar to national averages in gender distribution and average ACT scores, and the larger Arkansas institutions are similar in undergraduate enrollment to national averages. However, the medium Arkansas Master's institutions are smaller in undergraduate enrollment than both the national average for the medium category as well as the smaller category. All Arkansas institutions in the sample exceeded the national averages for percentage of White, non-Hispanic undergraduates enrolled and the percentage of students receiving Pell grants, while falling short of national averages for six-year graduation rates in all categories.

Table 5

Comparison of Undergraduate Education at Master's Universities and Colleges in Arkansas with National Population, Academic Year 2011-2012

Institutions[a] by Carnegie Level	Undergrad Enrollment	Race/ Ethnicity (% White)	Gender (% Female)	Pell Grants[b] (%)	Avg. ACT[c] 25th	Avg. ACT[c] 75th	Grad Rate[d] (%)
Larger							
ASU	10168	73	61	48	20	26	39
ATU	10089	81	56	46	18	25	41
UCA	9604	69	60	39	20	26	41
National (*n*=171)	10129	61	60	41	19	24	46
Medium							
HSU	3365	68	57	54	18	24	36
SAU	2865	65	60	55	18	24	35
National (*n*=61)	5882	60	59	42	19	24	42
Smaller							
UAM	3830	62	59	58	NA[e]	NA[e]	23
National (*n*=38)	4706	59	60	43	19	24	39

Source: National Center for Educational Statistics (NCES, http://nces.ed.gov/ipeds/datacenter/)
[a]Abbreviations for Arkansas institutions: ASU-Arkansas State University Main Campus; ATU-Arkansas Tech University; UCA-University of Central Arkansas; HSU-Henderson State University; SAU-Southern Arkansas University Main Campus; and UAM-University of Arkansas at Monticello.
[b]Pell Grants is the percentage of all undergraduate students receiving Pell grants in 2011-2012.
[c]Average ACT represents the Average ACT Composite score for the 25th percentile and 75th percentile of entering freshmen in Fall 2012.
[d]6-yr Grad Rate represents the percentage of first-time, full-time students who began studies in Fall 2006 and received a degree or award within 150% of "Normal Time" to completion for their program.
[e]UAM is an open admissions campus and does not report ACT scores of entering freshmen.

A comparison of the medium and smaller program characteristics in Table 5 indicated a high degree of similarity between the two program levels in the national samples, with undergraduate enrollment the main source of differentiation. Given that these designations were based on graduate degree production and this study was concerned with productivity and

efficiency at the undergraduate level, along with the identified similarities between program designations, the medium and smaller categories were collapsed into a single “medium-smaller” classification. Therefore, separate analyses were conducted for the 171 larger programs and the 99 medium-smaller programs. These group sizes exceeded the generally accepted DEA convention that the minimum number of DMUs in a DEA analysis should be more than three times the number of outputs plus inputs, which was a minimum of 18 [3(1+5)] institutions in this study (Lee, 2011).

Research Design

The analytical technique utilized in this study was data envelopment analysis (DEA). Specifically, the DEA portion of this analysis consisted of an output-oriented model that assumed variable returns to scale (VRS). The key construct in DEA methodology is technical efficiency. In an output-oriented DEA model, Farrell’s (1957) measure of technical efficiency is defined as the “maximum radial expansion in all outputs that is feasible with given technology and inputs,” as Farrell’s technical efficiency is the reciprocal of the Shephard (1953, 1970) distance function (Fried et al., 2008, p. 20). Charnes, Cooper, and Rhodes (1978) proposed DEA as a means for measuring the efficiency of decision-making units (DMUs) that could be "obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU be less than or equal to unity" (p. 430). DMUs with a ratio of 1.0 are considered to demonstrate technical efficiency, as these institutions create a piecewise linear efficiency frontier against which institutions with a ratio below 1.0, i.e., demonstrating technical inefficiency, can be measured (Johnes, 2006; Thanassoulis et al., 2008). The Charnes, Cooper, and Rhodes (CCR) model assumes constant returns to scale (CRS), while Banker, Charnes, and Cooper (1984) relaxed the CRS assumption in creating the BCC model,

allowing for variable returns to scale (VRS) that permits both increasing and decreasing returns to scale. The efficiency frontier created under the BCC model (VRS assumption) will more closely envelop the data set than an efficiency frontier under the CCR model (CRS assumption), as estimated efficiency results of the BCC model are typically higher than those estimated under CCR (Fried et al., 2008).

The efficiency scores generated by the two models differ in what they specifically represent. CRS-based efficiency scores indicate technical efficiency (TE) and measure inefficiencies caused by the configuration of inputs and outputs plus the size of the DMU, while VRS-based efficiency scores represent pure technical efficiency (PTE), which is a measure of efficiency without scale efficiency incorporated (Avkiran, 2001). Although a CRS model can be used instead of VRS, the two models can be used in conjunction, as the simple division of technical efficiency (CRS) by pure technical efficiency (VRS) provides the scale efficiency (SE) of a DMU (Agasisti & Johnes, 2009). According to Thanassoulis et al. (2008), "The larger the divergence between VRS and CRS efficiency ratings, the lower the value of scale efficiency and the more adverse the impact of scale size on productivity" (p. 290). With PTE and SE determined, additional analyses can be conducted to determine whether a DMU is experiencing increasing returns to scale (IRS) or decreasing returns to scale (DRS) (Thanassoulis et al., 2008). Determining local returns to scale is accomplished by re-running the DEA model with non-increasing returns to scale (NIRS) and comparing those results to the VRS efficiency scores; a DMU exhibits DRS if VRS scores equal NIRS scores, while a DMU exhibits IRS if VRS scores are not equal to NIRS scores (Avkiran, 2001). For the DMUs experiencing IRS or DRS, the Most Productive Scale Size (MPSS) can be calculated in order to determine the optimal scale size at which local CRS holds (Banker, 1984).

Due to the primary research questions concerning the estimation of institutional efficiency, DEA provided an additional benefit of being able to "benchmark" colleges and universities against one another to determine who is and is not functioning at an efficient level (Bogetoft & Otto, 2010). Given that DEA is a deterministic technique that relies on the data within the sample to distinguish between which institutions are operating on the efficiency frontier from those that are inefficient, DEA allows researchers and practitioners to identify benchmark institutions from which inefficient DMUs can learn (Archibald & Feldman, 2008; Sav, 2012). Within the performance-funding policy environment being examined in this study, the capacity of DEA to provide benchmark results has the potential for impacting how colleges and universities are viewed as it pertains to efficiency.

Similar to the methodological approach utilized by Wolszczak-Derlacz and Parteka (2011) in their study of higher education institutions across seven European countries, the DEA methodology used in this study incorporated Simar and Wilson's (1998, 2000, 2007) double-bootstrap technique within a two-stage, semi-parametric model in which efficiency estimates generated in stage one are regressed on exogenous variables in a second-stage truncated regression analysis. Variable returns to scale (VRS) was assumed in the study, as VRS is appropriate in instances where the DMU cannot adjust its scale of operation in the short-term, which is the case with colleges and universities (Lee, 2011). VRS also allows for the comparison of similar-sized institutions in order to determine variability in efficiency due to scale differences (Banker et al., 1984; Färe, Grosskopf, & Logan, 1983). An output orientation, as opposed to an input-oriented approach, was selected for this analysis, as the majority of higher education DEA-based research has used output-oriented models due to colleges and universities having limited capacity to increase the quantity and quality of inputs in the short-term (Bonaccorsi, Daraio, &

Simar, 2006; Worthington & Lee, 2008). Efficiency in an output orientation is determined by the ratio of a DMU's observed output to the maximum output achievable under existing input levels (Farrell, 1957). Within the current performance-funding policy environment, an institution's ability to maximize output within input constraints (i.e., efficiency) could be seen as a valuable measure of performance, a measure that is provided by the DEA methodology.

The purpose for using the two-stage approach in an output-oriented DEA model is to distinguish between inputs that an institution can control and those that are non-controllable (Johnes, 2006). In general, the use of two-stage approaches have followed an assumption that the non-controllable exogenous (environmental) variables serve as constraints related to input and output choices made by the institution (Simar & Wilson, 2007). The primary difference between a one-stage and a two-stage procedure is the assumption in the one-stage procedure that all inputs impact the process of producing outputs from inputs, whereas the assumption of the two-stage procedure is that environmental variables included in the second stage affect the efficiency of producing outputs from inputs (Lovell, 1993).

Simar and Wilson (2007) proposed the two-stage, semi-parametric DEA technique that incorporated a double-bootstrap algorithm as a means of addressing concerns related to DEA-based research found in the literature. The base DEA technique, because it is a non-parametric method, does not allow for either testing the statistical significance of the estimator that generates efficiency scores or understanding whether the estimator is consistent or biased (Simar & Wilson, 2008). Through the use of bootstrapping to generate a reasonable estimator of the unknown underlying data generating process (DGP), statistical analyses of the sampling distribution and bias adjustment of efficiency scores can occur, and inferences related to the DEA efficiency estimates can be made (Alexander, Haug, & Jaforullah, 2010; Simar & Wilson,

2008). Specifically, the bootstrapping procedure provides for the estimation of 95% confidence intervals for each institution's efficiency score, which allows for the determination of whether estimated efficiencies differ at a statistically significant level between universities (Johnes, 2006).

Simar and Wilson's methodology seeks to overcome deficiencies in the extant literature related to the studies that do not describe the underlying data generating process (DGP). Simar and Wilson (2007) argued that the lack of description of the underlying DGP provides "some doubt about what is being estimated in the two-stage approaches…that would make such regressions sensible" (pp. 32-33). Simar and Wilson's statistical model (i.e., the DGP) is considered to be "logically consistent with regressing non-parametric DEA efficiency estimates in a second stage regression on covariates (environmental variables) that are different from the inputs in the first stage" (Alexander et al., 2010, p. 102). The specification of a statistical model (DGP) also accounts for the censoring of the dependent variable (estimated efficiency scores) in the second stage regression analysis (Alexander et al., 2010).

Simar and Wilson's approach also attempts to address concerns related to what they argue have been invalid applications of ordinary least squares (OLS) and censored (Tobit) regression techniques in the majority of two-stage approaches in the literature (Simar & Wilson, 2007). The primary arguments against the validity of OLS and Tobit regression approaches are based on two types of correlation: DEA efficiency estimates generated in stage-one are serially correlated in an unknown fashion (Alexander et al., 2010), and the error term is correlated with the exogenous variables in the second-stage regression due to inputs and outputs from the stage-one DEA model being correlated with the environmental variables (Wolszczak-Derlacz & Parteka, 2011). The double bootstrap, two-stage truncated regression approach detailed by Simar

and Wilson (2007) provides a means for dealing with both types of correlation caused by the other two-stage regression techniques primarily utilized in the literature.

The double-bootstrap technique used in this research was based on Algorithm #2 introduced by Simar and Wilson (2007). This procedure includes a series of steps that are first delineated and then explicated further in the Research Questions section below. Alexander et al. (2010, p. 102) described the steps in non-technical terms as consisting of the following:

Step 1: Apply the DEA procedures to estimate efficiency scores for each institution.

Step 2: Carry out a truncated normal regression with the maximum likelihood method, regressing estimated efficiency scores on the environmental variables.

Step 3: Program a bootstrap from the truncated empirical normal distribution of the estimated efficiency scores.

Step 4: Calculate bias-corrected efficiency scores with the bootstrap results.

Step 5: Use bias-corrected efficiency scores to re-estimate the marginal effects of the environmental variables in the second-stage regression.

Step 6: Apply a second (double) bootstrap based on the empirical distribution of the bias-corrected second-stage regression.

Step 7: Construct bootstrap-based 95% confidence intervals for each parameter estimate.

Collection of Data

The Integrated Postsecondary Education Data System (IPEDS) (http://nces.ed.gov/ipeds/) served as the primary source for the collection of data used in this study. IPEDS is administrated by the National Center for Education Statistics and serves as the gatekeeper of data related to colleges and universities in the United States and includes several hundred continuous, string, and categorical data points spanning variable categories that include institutional characteristics,

admissions and test scores, fall enrollment, graduation rates, and finance. Data for the institutions in this study were collected via the IPEDS Data Center (http://nces.ed.gov/ipeds/datacenter/) through the "Compare Individual Institutions" portal. All data collected through the IPEDS Data Center was considered "final release data," which includes "revisions to the provisional release data that have been made by institutions during the subsequent data collection year" (NCES, 2014, http://nces.ed.gov/ipeds/datacenter/login.aspx). A three-step process was utilized for collecting data through the IPEDS Data Center: Select Institutions through the "By Group" feature, Select Variables through the "Browse/Search Variables" feature, and Output data that will be downloaded as a comma-separated values (CSV) file.

Four additional data sources were consulted for specific variables used in the second-stage procedure. The National Center for Higher Education Management Systems (NCHEMS) Information Center (http://www.higheredinfo.org/) was utilized to determine the percentage of adults 25- to 34-years-old with a bachelor's degree or higher. The U.S. Department of Commerce's Bureau of Economic Analysis (http://www.bea.gov/regional/index.htm) was accessed for the per capita real gross domestic product (GDP) by state data. Gorbunov's (2013) exhaustive list of cycles pertaining to adoption and latency of performance-funding policies was consulted to determine which states had performance-funding programs in existence during the 2011-2012 academic year under consideration in this study. Data from the "State Expenditure Report: Examining Fiscal 2011-2013 State Spending" (NASBO, 2013) provided data related to the higher education share of total state appropriations.

Output and Input Variables

The utilization of a two-stage approach requires the specification of input and output variables used in the stage-one DEA analysis, as well as the environmental variables included in

the stage-two truncated regression analysis. Given that DEA is an efficiency estimation technique, the terms "inputs" and "outputs" will be used in place of the typical "independent" and "dependent" variable designations, respectively. In the stage-two procedure, environmental variables, also referred to as exogenous variables, are the equivalent of "independent" variables in common use, while the "dependent" variable in the regression model was the stage-one DEA-estimated efficiency score for each institution in the sample.

Due to the non-parametric, deterministic nature of DEA, the selection of inputs and outputs to include in any model is a vital step in the implementation of a DEA-based procedure. One of the problems surrounding this issue is that "there is no definitive study to guide the selection of inputs/outputs in educational applications of DEA" (Avkiran, 2001). A search through recent literature failed to provide prescriptive guidelines related to initial input/output selection, as the focus of DEA is typically not on the inputs and outputs included in a model, but the efficient conversion of inputs into outputs (Worthington & Lee, 2008). While not specific in nature, general categories of inputs and outputs in higher education literature have been observed, as typical inputs include number of staff (academic and non-academic), number of students, and expenditures (non-labor, library, computing), while outputs include number of graduates, number of research projects, and publication-related (quantity and quality) measures (Katharaki & Katharakis, 2010).

Stage One: Output Variable

Although university output can be categorized in three domains (teaching, research, and service), performance-funding programs are primarily concerned with outputs that directly relate to the effectiveness of teaching at institutions of higher education. In the Arkansas performance-funding mandatory measures, "Number of bachelor's degrees earned" is the top outcome

specified, as Governor Mike Beebe's primary goal for higher education in Arkansas is doubling the number of college graduates by the year 2025 (ADHE, 2011). Across the DEA literature, number of graduates at various levels is by far the most often used output variable included in efficiency estimation analyses. Given the political and policy climate surrounding higher education, as well as research in the extant literature, the number of bachelor's degrees awarded by a university during the 2011-2012 academic year was the single output that served as a proxy for teaching output at the universities included in the study (Agasisti & Dal Bianco, 2009; Agasisti & Johnes, 2009; Agasisti, 2011; Flegg et al., 2004; Johnes, 2006, 2008; Parteka & Wolszczak-Derlacz, 2013; Wolszczak-Derlacz & Parteka, 2011; Worthington & Lee, 2008).

Stage One: Input Variables

The input variables included in the DEA estimation included factors associated with the general categories found throughout the DEA literature: students, staff, revenue, and expenditures. The following input variables were used in this study: total number of undergraduate students (Agasisti & Dal Bianco, 2009; Agasisti & Johnes, 2009; Flegg et al., 2004; Johnes, 2006, 2008; Parteka & Wolszczak-Derlacz, 2013; Wolszczak-Derlacz & Parteka, 2011); full-time equivalent academic staff (Agasisti & Johnes, 2009; Flegg et al., 2004; Johnes, 2006, 2008; Parteka & Wolszczak-Derlacz, 2013; Wolszczak-Derlacz & Parteka, 2011; Worthington & Lee, 2008); full-time equivalent administrative staff (Avkiran, 2001; Flegg et al., 2004; Lee, 2011; Worthington & Lee, 2008); total revenues (Agasisti & Dal Bianco, 2009; Parteka & Wolszczak-Derlacz, 2013; Wolszczak-Derlacz & Parteka, 2011); and total education and general expenditures (Flegg et al., 2004; Johnes, 2006, 2008).

Stage Two: Environmental Variables

Selecting environmental variables to be included in the second-stage regression offered a greater challenge than the stage-one input and output variables. While environmental variables used in the stage-two regression analysis are "primarily non-discretionary and expected to have some influence on the efficiency of universities" (Lee, 2011, p. 198), the general process of selecting these variables was hindered primarily due to the fact that the "distinction between decision-maker controlled and environmental variables is not always distinct" (McMillan & Chan, 2006, p. 11). Sav (2013) highlighted the complex nature of higher education research as it relates to estimating efficiency, indicating factors such as the source and proportion of financial support can be viewed as being "quasi environmental factors" that can be considered both "partially exogenous and partially under the control of university management" (p. 64). The lack of clear delineation between controllable and non-controllable factors in higher education served as a challenge in selecting which to include as inputs in stage one or environmental variables in stage two.

Additionally, published research specifically applying Simar and Wilson's (2007) approach to the context of higher education is sparse, especially in the United States. Wolszczak-Derlacz and Parteka (2011) conducted one of the few studies that utilized Simar and Wilson's (2007) approach in higher education research, as their study of institutions across seven European countries included six exogenous variables in their second-stage truncated regression: country gross-domestic product (GDP), number of faculties, a dummy variable for the existence of a medical school, year the institution was founded, proportion of women employed in academic positions, and proportion of university revenues from non-governmental sources. The authors found that each of these variables, except for national GDP, was significantly associated

with DEA estimated efficiency scores, as these values failed to fall within the 99% confidence interval estimates (Wolszczak-Derlacz & Parteka, 2011). Lee (2011) also used Simar and Wilson's technique in studying Australian universities, including student load factor, university location (city or non-city), proportion of Associate Professors and Professors to academic staff, and Institutional Grants Scheme as exogenous variables in the stage-two regression. Lee (2011) found that all four variables were statistically significantly ($p < .05$) related to institutional efficiency as measured by the stage-one DEA estimates.

A broader search of the literature including two-stage regression approaches using different regression techniques (Tobit and OLS) provided additional studies from which environmental variables could be considered for this study. In their study of the efficiency of 72 German institutions, Kempkes & Pohl (2010) regressed DEA efficiency estimates on three environmental factors: regional GDP per capita, and the presence of engineering and/or medical departments at the institution, finding that all three exogenous factors were statistically significant at their designated threshold ($p < 0.10$). Agasisti (2011) compared efficiency of national higher education systems across 18 countries in Europe and included five exogenous variables: GDP per capita, expenditure per student, percentage of students in public universities, percentage of public funding compared to total resources, and average years of education. Of these five environmental variables, GDP per capita ($p < 0.05$) and average years of education ($p < 0.01$) were the variables that were found to be statistically significant when all variables were considered in the model (Agasisti, 2011). Using three financial quasi-exogenous variables (percentage of funding from tuition charges, government appropriations, and investment income), Sav (2013) found that greater dependency on tuition-based funding led to greater inefficiency, as tuition dependency was statistically significant in this study ($p < .01$). The

complementary construct of a higher proportion of government funding led to higher levels of efficiency at the institutional level, albeit not at a statistically significant level (Sav, 2013).

The primary objective of the second-stage regression procedure is to "associate variation in producer performance with variation in exogenous variables characterizing the environment in which production occurs" (Kumbhakar & Lovell, 2003, p. 261). Within this conceptualization, and based on a review of literature associated with the primary domains considered in this study (performance-funding policy, principal-agent relationship, privatization of higher education, and single-stage DEA and two-stage regression approaches), the following environmental variables were included in the second-stage truncated regression model:

- per capita real gross domestic product (GDP) by state during 2012 (Agasisti et al., 2011; Kempkes & Pohl, 2010; Wolszczak-Derlacz & Parteka, 2011);
- net tuition share of operating revenues in 2011-2012 (Sav, 2012);
- percentage of the state's population (25 – 34 years old) with a bachelor's degree or higher in 2012 (Agasisti et al., 2011);
- higher education's share as a percent of state's total expenditures in 2012; and,
- existence of state performance-funding program during 2011-2012.

The last four variables, while either minimally or not specifically found in the cited DEA research as environmental variables, were important in being able to explore the impact these variables have on institutional efficiency and explaining the inter-relationship between the primary areas of concern in this study. While Sav (2012) included net tuition share of operating revenues as a statistically significant factor in his analysis, this environmental variable will also address growing concerns in higher education policy regarding increased privatization and reliance on tuition and fees as a means for overcoming decreasing levels of state support

(Hossler, 2004; John & Parsons, 2005; SHEEO, 2014). Although Agasisti et al. (2011) considered percentage of the state's population with a bachelor's degree as an output variable in their DEA estimation, this study will incorporate this variable as a factor that might explain some of the variance in institutional efficiency when considering the environmental situations in which these institutions operate. Restricting this variable to 25- to 34-year-olds addresses the demographic group that has been identified as one of the United States' primary concerns related to international competition, as the U.S. ranks 12th internationally in the percentage (43% in 2011) of 25- to 34-year-old adults that have attained "tertiary education," which is 21 percentage points behind Korea, the leading country in this category (64% in 2011) (OECD, 2013).

Including higher education's share of state total expenditures served as a measure of the state's commitment toward supporting higher education, an important environmental factor which has steadily decreased over the past three decades (Delaney & Doyle, 2007; McLendon, Hearn, et al., 2009; NASBO, 2013; Okunade, 2004; Rizzo, 2006; Tandberg & Griffith, 2013). The existence of an active performance-funding program in states during 2011-2012 provided an avenue for exploring whether there is a link between performance-funding and institutional efficiency, as most existing research has concentrated on the effect of performance funding on state budgetary practices, institutional spending priorities, graduation rates, research funding, budget allocation, and policy innovations (Archibald & Feldman, 2008; Hearn, Lewis, Kallsen, Holdsworth, & Jones, 2006; McLendon et al., 2005; Rabovsky, 2012; Shin, 2010). Appendix B provides the variables, including definitions and source, used in both stages of analysis.

Research Questions

This section details how results from the 7-step procedure adapted from Simar and Wilson's (2007) Algorithm #2 were utilized to answer each of the posited research questions

included in this study. Due to the grouping of institutions into two categories (larger and medium/smaller), the full multi-step process was carried out separately for each group of institutions in this study. From a practical data analysis perspective, all statistical analyses in this study will be conducted using R: A Language and Environment for Statistical Computing (*R: A Language and Environment for Statistical Computing*, 2014), as the primary R packages that will be used include FEAR 2.0.1 (Wilson, 2008), Benchmarking in R (Bogetoft & Otto, 2013), and truncreg: Truncated Gaussian Regression Models (Croissant & Zeileis, 2013). The following section includes a restatement of the research questions posited in chapter 1, with a detailed description of the analytical processes that will be followed to answer each particular question.

Question 1: When compared to similar institutions nationally, how efficient are four-year public Master's universities in Arkansas at utilizing resources to achieve one of the mandatory measures (bachelor's degrees awarded) required by the new performance-funding program?

In order to estimate the efficiency of the Arkansas universities under consideration, steps 1, 3, 4, and 5 of the 7-step process outlined in the "Research Design" section of this chapter were completed. Step 1 provided the original DEA estimates of CRS-based technical efficiency and VRS-based pure technical efficiency for each institution in this study. From these efficiency estimates, institutions can be compared based on their pure technical efficiency score, which will serve as an indicator of how efficient the Arkansas universities in this study were in comparison to similar institutions nationally. To determine whether differences in efficiency among institutions are statistically significant, Steps 3-5 will be conducted in order to make statistical inferences regarding the estimated efficiency scores generated in the original DEA procedure. The ability to conduct statistical analysis through the creation of 95% confidence intervals for the

bootstrapped technical efficiency estimates created in Steps 3-5 enhanced the results of this study by correcting for bias in the original DEA estimation procedure (Simar & Wilson, 1998).

Question 2: Which environmental factors contribute to the estimated efficiency of the inefficient four-year public Master's Colleges and Universities included in this study?

All seven steps in the double-bootstrapped, two-stage truncated regression analysis were utilized in order to answer this research question. While other regression techniques, primarily censored (Tobit) and OLS regression, have been utilized in two-stage procedures that regress stage-one DEA estimated efficiencies on environmental variables, Simar and Wilson (2007) argued that previous analytical approaches failed to describe the underlying, unknown data generating process (DGP), causing "some doubt about what is being estimated in the two-stage approaches" (p. 32). Typically used two-stage techniques have also failed to account for the serial correlation of DEA efficiency estimates that arise in finite samples, essentially invalidating these inference-making approaches (Simar & Wilson, 2007). Simar and Wilson conducted a Monte Carlo experiment with 1,000 trials in order to compare Tobit regression and truncated regression techniques within the Algorithm #2 procedure, finding that the Tobit regression model was severely mis-specified, resulting in estimated confidence intervals that were not near the true values (Simar & Wilson, 2007).

The determination of which environmental factors contributed to institutional efficiency was made through an examination of the parameter estimates and 95% confidence intervals resulting from the double bootstrap truncated regression analysis. The efficiency scores created in stage one of the procedure served as the dependent variable in the truncated regression analysis, as the environmental variables that were per capita GDP by state, net tuition revenue, educational attainment of 24-34 year olds in the state, higher education share of state total

expenditures, and the existence of performance-funding program during 2011-2012. The 95% confidence intervals constructed in Step 7 will provide data that will allow for statistical inferences to be made regarding the impact of these environmental variables on institutional efficiency. The threshold for statistical significance was established at $p < .05$.

Question 3: Does the existence of a performance-funding program impact the estimated institutional efficiency of the four-year public Master's Colleges and Universities included in this study?

In order to answer this research question, the results of the analysis performed to answer question #2 were used to determine whether a link exists between the existence of a performance-funding program and institutional efficiency estimated through the DEA procedure in Step 1. The parameter estimate and 95% confidence interval constructed in Steps 4, 5, 6, and 7 served as the data that were examined to explore the impact of the existence of performance-funding programs on institutional efficiency. The threshold for statistical significance was established at $p < .05$.

Question 4: What are the policy implications related to institutional efficiency within Arkansas' performance-funding program?

The conceptual framework utilized in this study was agency theory. Agency theory examines the contractual relationship between a principal and agent that is characterized by both parties acting as rational, self-interested maximizers (Ghoshal, 2005). At the core of agency theory is the agency problem, which results from the principal delegating aspects of the decision-making process to the agent, which also provides an opportunity for the agent to choose self-interested actions that may diverge from the goals and interests of the principal (Jensen & Meckling, 1976). The two constructs that serve as the "spark plugs that power (agency) theory"

(Waterman & Meier, 1998, p. 177) are informational asymmetries and goal conflicts, as agency theory is primarily concerned with understanding how principals attempt to coerce or incentivize agent actions that will maximize the potential for achieving the principal's goals and objectives (Lane, 2012). Within institutions of higher education, informational asymmetries exist at multiple levels due to the complexities of the organizational structure and the specialized expertise required in the academic work of teaching and research (Kivistö, 2008).

This study explored the key constructs of agency theory as represented by the contractual relationship between state government and institutions of higher education found in the performance-funding program in Arkansas. Arkansas's re-implementation of a performance-funding program, along with the expansion of performance outcomes and the restructuring of performance-based allocations being tied to base funding (25% in 2017-2018) (ADHE, 2011), were conceptualized as an attempt by the principal to decrease informational asymmetries and goal conflicts by designing a monitoring and incentive structure that mitigates the potential for agent-driven adverse selection and moral hazard (Moe, 1984).

One of the primary policy implications of this research was related to establishing peer institutions against which Arkansas' universities can be benchmarked. One of the primary benefits of DEA-based techniques is that institutions are compared to peers that represent "best practices" related to institutional efficiency, as compared with regression-only techniques that compare institutional efficiency to average practice (Archibald & Feldman, 2008). The benchmarking process was achieved through the calculation of DEA efficiency estimates in stage-one of the two-stage analytical procedure. Through the application of the DEA procedure in Step 1, an efficiency frontier was estimated that was comprised of institutions that demonstrated technical efficiency, as institutions that demonstrated technical inefficiency (based

on an efficiency score below 1.0) were located away from this efficiency frontier. Based on where inefficient institutions reside beneath the efficiency frontier, peer institutions can be determined, which provide an opportunity for inefficient institutions to learn from institutions that are operating efficiently.

Another policy implication examined was the determination of which exogenous variables contribute to the estimated efficiency of Arkansas institutions. The stage-two truncated regression analysis determined whether and to what extent these variables had a statistically significant impact on institutional efficiency during the 2011-2012 academic year. Sav (2013) argued that public institutions have had to shift their financial dependency due to state funding reductions, as the "new pressures have been brought to bear on university management to seek ways of improving operating efficiencies with ever tighter budgetary constraints" (p. 63). The results of the second stage regression analysis provided policymakers with information related to which of the environmental factors included in the regression analysis promote efficiency at public institutions, as this information could be utilized in future decision-making processes. In general, the analytical technique used in this study could serve as a model that could be incorporated into the performance-funding mechanism that currently exists in Arkansas. At present, all of the mandatory, optional, and compensatory measures included in the performance-funding program address various performance outcomes and do not include a measure of how efficiently institutions achieve those outcomes. This study demonstrated an analytical technique that has the potential to be an addition to the existing performance-funding program that will expand the performance measures to include an efficiency component.

Chapter Summary

This chapter has explicated the details concerning the analytical technique that will be utilized in this study. The sample institutions examined consisted of the four-year public universities in Arkansas that have the Carnegie Classification of "Master's Colleges and Universities." The six Arkansas institutions were compared to the national population of Master's Colleges and Universities spanning all three categories: larger programs, medium programs, and smaller programs. Due to similar characteristics, the 99 medium and smaller programs were analyzed together, with the 171 larger programs analyzed in a separate group. Building on the methodology introduced by Simar and Wilson (2007), this study used a 7-step procedure to conduct a double-bootstrap, two-stage truncated regression analysis. Grounded in data envelopment analysis (DEA), institutional efficiency was initially estimated in Step 1 within an output-oriented framework with an assumption of variable returns to scale (VRS). This stage-one procedure produced an efficiency frontier comprised of institutions demonstrating technical efficiency (based on a ratio score of 1.0), as institutions not located on this frontier were considered to be demonstrating technical inefficiency (based on a ratio score < 1.0). The estimation of pure technical efficiency under the VRS assumption, coupled with technical efficiency under the constant returns to scale (CRS) assumption, allowed for the calculation of a variety of measures related to institutional efficiency: scale efficiency, non-increasing returns to scale, increasing returns to scale, and decreasing returns to scale. Steps 2-7 of the analytic approach used in this study provided a means for estimating the influence of environmental variables on institutional efficiency, as the DEA-based efficiency estimates were regressed on five exogenous variables in the second-stage truncated regression model. Bootstrap procedures introduced by Simar and Wilson (2007) were used throughout the multi-step process in order to

correct for bias inherent in the non-parametric DEA estimations, as well as provide for statistical inferences through the construction of 95% confidence intervals around both the stage-one efficiency estimates and the stage-two parameters. The following chapter presents results of the analytical procedures detailed in Chapter 3.

CHAPTER IV

RESULTS

In 2011, the Arkansas legislature passed Act 1203, which served to re-institute, for a fourth time, a performance-funding program for higher education in the state. This new iteration holds several tenets of what has been deemed Performance Funding 2.0:

- Shifted performance-based funds from a bonus structure to being incorporated in base funding;
- Increased the proportion of funding tied to performance outcomes to 25% of base funding once fully implemented in FY 2018;
- Created mandatory measures for four-year institutions that included the number of bachelor's degrees, total credentials, and STEM credentials awarded, along with a new progression measure that accounted for the successful progression of all credential-seeking students.

This performance-funding program serves as heightened accountability for increasing production of these educational outcomes within a context of proportionally declining levels of state financial support. The concept of increasing outputs without increasing inputs is a simple definition of improving efficiency. Although efficiency was mentioned in Act 1203, even appearing in the title of the legislation, a measure of efficiency was not included in the implemented program. This study sought to estimate the efficiency of four-year Master's universities in Arkansas while providing a measure of institutional efficiency that could be included in future modifications of the performance-funding program in Arkansas. In order to examine the results of this study, this chapter includes major sections and subsections that provide a summary of the study, data collection results, data analysis, and a chapter summary.

Summary of the Study

The purpose of this study was to explore the contractual relationship between the state of Arkansas and its public colleges and universities through the lens of agency theory, while also estimating the efficiency of a segment of those institutions (public Master's universities) in producing one of the mandatory measures included in the performance-funding program: number of bachelor degrees awarded. This study is significant in that it utilized agency theory as a conceptual framework to explain how the new iteration of performance-funding in Arkansas can be viewed as a contractual agreement between the state and higher education institutions, in which the state (principal) is attempting to coerce institutions (agents) via incentives to increase the production of degreed and credentialed citizens in order to meet the economic and workforce needs of the state. This study is also significant in that it applied an analytical methodology that, to the best of my knowledge, has not been used in a study of Master's colleges and universities in the United States.

Research Design

The analytical technique utilized in this study was based on Simar and Wilson's (2007) two-stage double bootstrap truncated regression technique. This technique combines the use of data envelopment analysis (DEA), which is a non-statistical, non-parametric approach to estimating efficiency of decision-making units (DMUs), with bootstrapping and regression-based methods that provide a means of overcoming deficiencies in the base DEA technique. Through bootstrapping, bias-corrected technical efficiency estimates can be calculated, allowing for statistical inferences regarding the underlying data generating process to be made. The second-stage truncated regression analysis allows for the regressing of environmental variables, which

are generally beyond the control of the DMU, on the DEA efficiency estimates in order to determine which, if any, environmental variables influence estimated efficiency scores.

The DEA portion of this analysis consisted of an output-oriented model that assumed variable returns to scale (VRS). The double-bootstrap technique used in this methodology was based on Algorithm #2 introduced by Simar and Wilson (2007). The technique used in this study included the following steps (based on Anderson's (2010) non-technical description of the approach):

Step 1: Apply the DEA procedures to estimate efficiency scores for each institution.

Step 2: Carry out a truncated normal regression with the maximum likelihood method, regressing estimated efficiency scores on the environmental variables.

Step 3: Program a bootstrap from the truncated empirical normal distribution of the estimated efficiency scores.

Step 4: Calculate bias-corrected efficiency scores with the bootstrap results.

Step 5: Use bias-corrected efficiency scores to re-estimate the marginal effects of the environmental variables in the second-stage regression.

Step 6: Apply a second (double) bootstrap based on the empirical distribution of the bias-corrected second-stage regression.

Step 7: Construct bootstrap-based 95% confidence intervals for each parameter estimate.

Data Collection

The Integrated Postsecondary Education Data System (IPEDS) (http://nces.ed.gov/ipeds/) served as the primary source for the collection of data used in this study. IPEDS is administrated by the National Center for Education Statistics (NCES), which maintains data related to colleges and universities in the United States. The IPEDS database includes several hundred continuous,

string, and categorical data points spanning variable categories that include institutional characteristics, admissions and test scores, fall enrollment, graduation rates, and finance. For the calculation of the input variable *net tuition share* that was used in the second-stage regression analysis, this study followed the calculation conducted by the Delta Cost Project, using variables collected through IPEDS (http://www.deltacostproject.org/). This variable was not available through the Delta Cost Project's dataset, which currently includes data through FY 2010. Data were also collected from four additional sources: the National Center for Higher Education Management Systems (NCHEMS) Information Center (http://www.higheredinfo.org/); the U.S. Department of Commerce's Bureau of Economic Analysis (http://www.bea.gov/regional/index.htm); Gorbunov's (2013) exhaustive list of cycles pertaining to adoption and latency of performance-funding policies; and the National Association of State Budget Officers' "State Expenditure Report: Examining Fiscal 2011-2013 State Spending" (NASBO, 2013).

Data Collection Results

Data were collected for the national population of 270 four-year public institutions in the United States that are classified as Master's Colleges and Universities by the Carnegie Foundation. Master's institutions are those which produce fewer than 20 doctoral research degrees annually, as the Carnegie classification system delineates Master's programs into three categories based on annual awarding of master's degrees: smaller (50-99 master's degrees), medium (100-199 master's degrees), and larger (at least 200 master's degrees) programs (Carnegie Foundation for the Advancement of Teaching, 2014). The national population of four-year, public Master's institutions consists of 171 larger, 61 medium, and 38 smaller programs.

An initial data set was constructed for the stage-one output (bachelor_degrees) and input variables (undergraduates, academic_staff, admin_staff, revenues, and expenditures), and the stage-two environmental variables (GDP, net_tuition, attainment, share, and performance_funding). An initial review of demographic and academic preparation characteristics of medium and smaller institutions indicated a high level of homogeneity between the groups. Given these similarities and that the two medium institutions in Arkansas (Henderson State University and Southern Arkansas University) have undergraduate enrollments below the mean for the programs classified as smaller Master's institutions in the national population, the medium and smaller programs were grouped together throughout the analyses conducted in this study. Due to missing data, there were four institutions excluded from the Master's larger campus group, reducing the analyzed sample to 167 larger group institutions. The medium/smaller category was reduced by six institutions that had missing data, resulting in the analysis of 93 institutions in this combined grouping. Each of the 260 institutions with complete data were included in both the stage-one estimation of DEA efficiency and the stage-two truncated regression analysis.

Data Analysis

The following section is comprised of two subsections: the first includes a presentation of descriptive statistics and initial results for the larger and medium/smaller groups of institutions, and the second subsection includes answers to the research questions based on results from the multi-step procedure used in this study. From a practical data analysis perspective, all statistical analyses in this study were conducted using R: A Language and Environment for Statistical Computing (2014), as the primary R packages used included FEAR 2.0.1 (Wilson, 2008), Benchmarking in R (Bogetoft & Otto, 2013), and truncreg: Truncated Gaussian Regression

Models (Croissant & Zeileis, 2013). The double bootstrap truncated regression Algorithm #2 (Simar & Wilson, 2007) was conducted via a function written in R by H. S. Nghiem (personal communication, August 20, 2014).

Descriptive Statistics for Institution Groups

After removing institutions for missing data, the sample included in the study represented 97.7% of all larger programs (167 of 171) and 93.9% of all medium/smaller programs (93 of 99) classified as four-year public Master's Colleges and Universities in the United States. Appendix B presents descriptive statistics by group for each of the stage-one output and input variables, as well as the stage-two environmental variables. For the medium/smaller group, the average annual production of bachelor's degrees during the 2011-2012 academic year was 928 and ranged from a minimum of 106 to a maximum of 2,691. The average undergraduate population in this group was 4,962 students with a range spanning from 1,102 to 18,481 students. The average revenue, as defined in the study, was $51.89 million with a minimum revenue of $8.75 million and a maximum revenue of over $202 million, while total education and general expenditures ranged from a minimum of $21.83 million to a maximum of $184.76 million with an average expenditure of $76.26 million for the institutions in the medium/smaller group. Institutions in the larger group produced an average of 1,917 bachelor's degrees (range of 198 to 7,044) in 2011-2012. The undergraduate population at the larger Master's institutions included in this study ranged from 1,450 to 31,747, as the average undergraduate enrollment was 9,918 for this group. The average revenue for the Master's larger group of institutions was $104.73 million in 2011-2012, with a minimum revenue of $8.36 million and a maximum revenue in excess of $339.92 million. Total education and general expenditures for the larger group institutions ranged from $20.78 million to $432.70 million with an average of just over $157 million.

By comparison, Table 6 shows the original values for the output, input, and environmental variables for the six Arkansas Master's institutions included in the study. In the stage-two truncated regression analysis, the environmental variables included for the Arkansas institutions for the state's per capita real GDP during 2012 was $38,336; higher education's share as a percentage of the state of Arkansas's total expenditures in 2012 was 16.2%; and the percentage of the state's population (25-34 years old) with a bachelor's degree or higher in 2012 (attainment variable) was 23.08%.

Table 6

Descriptive Statistics of Output, Input, and Environmental Variables for Arkansas Institutions, 2011-2012 Academic Year

Institutions[a]	Bachelor Degrees	Under-graduates	Acad Staff (FTE)	Admin Staff (FTE)	Rev-enues ($)	Expen-ditures ($)	Tuition Share (%)
Larger Group							
ASU	1,687	9,455	551	61	88,943,766	153,765,289	69.17
ATU	1,214	8,369	383	64	66,521,807	88,948,308	55.48
UCA	1,619	8,956	590	44	80,212,920	132,494,894	57.23
Medium/ Smaller Group							
HSU	507	3,365	197	26	21,178,555	44,629,743	48.62
SAU	406	2,682	180	31	17,935,095	35,161,884	51.18
UAM	380	3,280	180	35	17,918,502	43,273,638	30.32

[a]Abbreviations for Arkansas institutions: ASU-Arkansas State University Main Campus; ATU-Arkansas Tech University; UCA-University of Central Arkansas; HSU-Henderson State University; SAU-Southern Arkansas University Main Campus; and UAM-University of Arkansas at Monticello.

DEA Efficiency Estimations for Institution Groups

The two-stage procedure used in this study produced, in part, both original DEA technical efficiency estimates and bias-corrected technical efficiency estimates that included 95% confidence intervals. Of the 270 institutions in this study, only two institutions had original

technical efficiency scores contained within the 95% confidence interval bands indicating statistical significance. For each group, the original technical efficiency estimates were correlated with the bias-corrected estimates, as the larger group estimates were correlated at 0.98, while the medium/smaller group estimates were correlated at 0.97. Due to these initial findings, the remainder of the presentation of results from the DEA-based analyses will consist of the original DEA technical efficiency estimates.

The DEA model used in this study assumed an output orientation with variable returns to scale (VRS). An output-oriented model was selected due to the majority of DEA-based research in higher education having used output-oriented models, as colleges and universities have limited capacity to increase the quantity and quality of inputs in the short-term (Bonaccorsi et al., 2006; Worthington & Lee, 2008). VRS was appropriate in this study, as VRS is used when DMUs cannot adjust their scale of operations in the short-term, which is the case with colleges and universities (Lee, 2011). Constant returns to scale (CRS) were calculated in order to determine scale efficiency (SE) scores, and non-increasing returns to scale (NIRS) were calculated in order to determine whether institutions exhibited increasing returns to scale (IRS) or decreasing returns to scale (DRS).

In order to demonstrate graphically the differences between the three types of returns to scale, Figure 3 was created for the 93 institutions that comprised the medium/smaller group in this study. Figure 3 consists of one input (expenditures) and one output (number of bachelor's degrees awarded) included in the DEA model. As can be seen in Figure 3, the efficiency frontier under the VRS assumption more closely envelopes the data than does the line produced by the CRS assumption, which represents a primary difference between the two types of returns to scale (Fried, Lovell, & Schmidt, 2008). DRS initially follows the CRS line, but mirrors VRS after

reaching the initial efficient institution on the frontier as determined under CRS. The efficiency frontier in the output-oriented model, which is comprised of institutions with a technical efficiency score of 1.0, has only four institutions in the one input/one output model shown in Figure 3, although more institutions were found to exhibit technical efficiency within the full DEA model. The relationship between efficient and inefficient institutions will be further explored in the discussion below.

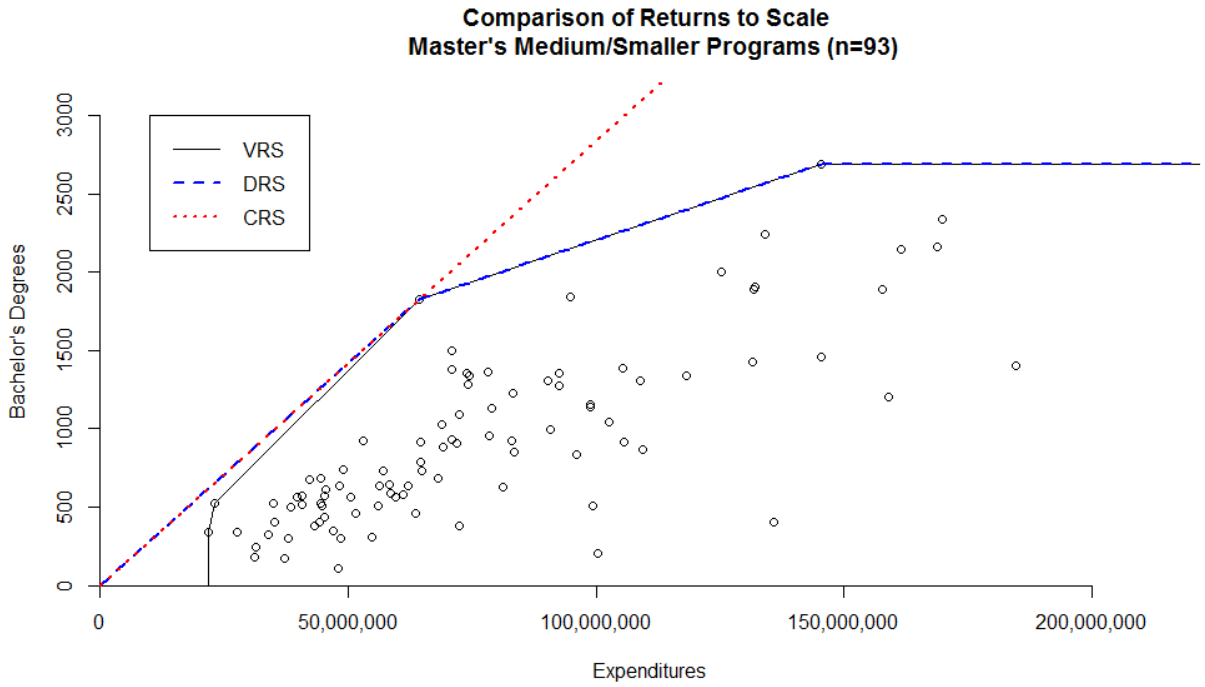


Figure 3. Comparison of returns to scale for medium/smaller programs in the study.

Determination of Scale Efficiencies in Stage-One DEA Model

In order to further analyze the efficiency of the Master's institutions included in this study, additional DEA estimates were calculated under the assumption of constant returns to scale (CRS). Table 7 provides descriptive statistics for VRS, CRS, and scale efficiency (SE) for each group in the study. SE is calculated as $\frac{CRS}{VRS}$, such that lower SE scores represent a greater divergence between VRS and CRS, indicating that scale size has a more adverse impact on

institutional productivity (Thanassoulis et al., 2008). Given that efficiency scores under the CRS assumption, by definition, include scale inefficiencies, CRS estimates will always be lower than VRS, given that VRS estimates do not include scale inefficiencies when calculated (Agasisti & Johnes, 2009). Each of the efficiency measures in Table 7 are comprised of ratios between 0 and 1. For VRS and CRS technical efficiency estimates, institutions with an efficiency score of 1.0 are considered technically efficient and define the efficiency frontier against which the inefficient institutions (efficiency < 1.0) are measured.

Table 7

Descriptive Statistics for Efficiency Measures by Group, 2011-2012

	Mean	Standard Deviation	Median	Minimum	Maximum
Larger Group (*n*=167)					
VRS	0.755	0.156	0.757	0.326	1.000
CRS	0.738	0.155	0.741	0.296	1.000
SE	0.977	0.031	0.990	0.855	1.000
Medium/Smaller Group (*n*=93)					
VRS	0.715	0.197	0.711	0.284	1.000
CRS	0.640	0.180	0.640	0.219	1.000
SE	0.905	0.114	0.938	0.219	1.000

The average VRS score, based on the Shephard (1970) output distance function, for the larger group of institutions was 0.755 (*sd*=0.156) and was 0.715 (*sd*=0.197) for the medium/smaller group. For the larger group of institutions, 9% (15 of 167) exhibited technical efficiency with a VRS score of 1.0, while 12% (11 of 93) of the medium/smaller institutions were technically efficient. These technical efficiency estimates suggest that the larger group and the medium/smaller group institutions, if they were collectively producing bachelor's degrees on the efficiency frontier, could respectively utilize only 76% and 72% of their existing inputs to produce the same number of outputs (Blalark, 2012). With the original model constructed using

an output-oriented approach, the DEA technique provided for the calculation of the proportional decrease in inputs needed for institutions to become technically efficient given their existing level of output. Based on the mean VRS scores in Table 7, larger institutions could, on average, reduce the amount of each input included in the DEA model by at least 24.5% [(1-VRS)*100%] in order to produce the same number of bachelor's degrees efficiently, while the collective medium/smaller institutions could decrease each input by an average of 28.5% in order to produce the same number of bachelor's degrees efficiently.

A complement to the Shephard output distance function efficiency estimates is Farrell technical efficiency, which is calculated by taking the reciprocal of the Shephard-based estimates. Under an output-orientation, institutions with a Farrell technical efficiency score of 1.0 are deemed technically efficient, while efficiency scores above 1.0 indicates technical inefficiency. The Farrell technical efficiency score, under an output-oriented DEA approach, allows for the calculation of how much an inefficient DMU would need to increase its output(s), based on given inputs, in order to reach the efficiency frontier (Wolszczak-Derlacz & Parteka, 2011). This percentage increase is calculated as [(Farrell efficiency score – 1)*100%] (Wolszczak-Derlacz & Parteka, 2011). The mean Farrell technical efficiency score was 1.392 (*sd*=0.345) for larger institutions and 1.530 (*sd*=0.504) for medium/smaller institutions. From an output maximization perspective, the institutions in the larger group could increase their output (bachelor's degrees) by 39.2% given existing levels of inputs, while medium/smaller institutions could, on average, increase their output of bachelor's degrees by 53% while keeping input levels stable. Across both groups in the study, the maximum Farrell technical efficiency score was 3.526, which means that this institution would need to increase its bachelor's degree production

by 252.6% within the existing levels of inputs in order to reach the efficiency frontier as determined by the DEA model used in this study.

Table 7 also provides results from the calculation of scale efficiency (SE) of institutions included in this study, as SE is a measure of "how far the scale size of a unit is away from 'optimal'" (Thanassoulis et al., 2008, p. 290). The mean scale efficiency (SE) score for larger institutions was 0.977 (*sd*=0.031) and for medium/smaller institutions was 0.905 (*sd*=0.114). The high level of scale efficiency demonstrated by both groups indicated that, on average, the institutions in this study were operating close to their optimal size. For the larger institution group, 6.6% (11 of 167) of institutions had an SE score of 1.0, while 3% (3 of 93) of the medium/smaller institutions had an SE score of 1.0.

Determination of Peers in Stage-One DEA Model

One of the primary benefits and distinguishing features of DEA-based approaches is the ability to benchmark inefficient DMUs against efficient DMUs that are operating on the efficiency frontier. From a practical perspective, the selection of benchmarks, i.e., peers, is of great importance to DMUs who desire to learn from other institutions that are technically efficient (Hougaard & Tvede, 2002). The estimation of efficiency in the stage-one DEA model provided a set of peers and peer weights that consisted of the 11 medium/smaller institutions that were deemed technically efficient with a VRS efficiency estimate of 1.0, while 15 peers were identified in the group of larger institutions. Table 8 identifies the peers in each group, as well as the number of times each efficient institution served as a peer in the DEA model. Two institutions (State University of New York at New Paltz and California State University-Chico) served as peers for more than 100 of the 167 institutions in the larger group, while three institutions (Metropolitan State University, University of South Florida-Sarasota-Manatee, and

The Evergreen State College) were peers for 60 or more of the 93 institutions included in the medium/smaller group.

Table 8

Frequency with which an efficient institution appeared as a peer in the DEA model

Institution Name	Number of times institution is a peer
Larger Group	
State University of New York at New Paltz	105
California State University-Chico	102
Fort Hays State University	89
Texas A & M University-Texarkana	72
California State University-Fullerton	31
University of Houston-Victoria	30
Governors State University	24
California State University-East Bay	15
California State University-Bakersfield	6
California State University-Fresno	4
California State University-Sacramento	3
Peru State College	3
California State Polytechnic University-Pomona	2
California State University-Long Beach	2
California State University-Northridge	1
Medium/Smaller Group	
Metropolitan State University	76
University of South Florida-Sarasota-Manatee	65
The Evergreen State College	60
Central Washington University	13
The Richard Stockton College of New Jersey	11
Southwest Minnesota State University	8
Weber State University	4
Eastern Oregon University	4
Cheyney University of Pennsylvania	3
University of Alaska Southeast	2
Northwestern Oklahoma State University	2

In order to explore the peer concept graphically, Figure 4 was created to show the relationship between peers, inefficient institutions, and the efficiency frontier. As seen in Figure 3, the efficient institutions that are peers for more than 20 institutions in the larger group of

Master's universities are demarcated by a red square. In the DEA modeling phase of this study, peers were determined based on results of the full model consisting of all five input variables and one output variable. In Figure 3 below, the plot utilizes just one input (undergraduate enrollment) and one output (number of bachelor's degrees awarded) to construct the efficiency frontier based on an output-oriented, VRS model in order to demonstrate the concept. Five of the seven peers identified in Figure 3 lie directly on the efficiency frontier. The two institutions located just below the efficiency frontier, while not 100% efficient with a single input variable (undergraduate enrollment) in the model, were deemed technically efficient by the full model with all five input variables included. Figure 3 also highlights the relative nature of the DEA technique, in which efficiency and inefficiency are determined relative to the other institutions included in the model.

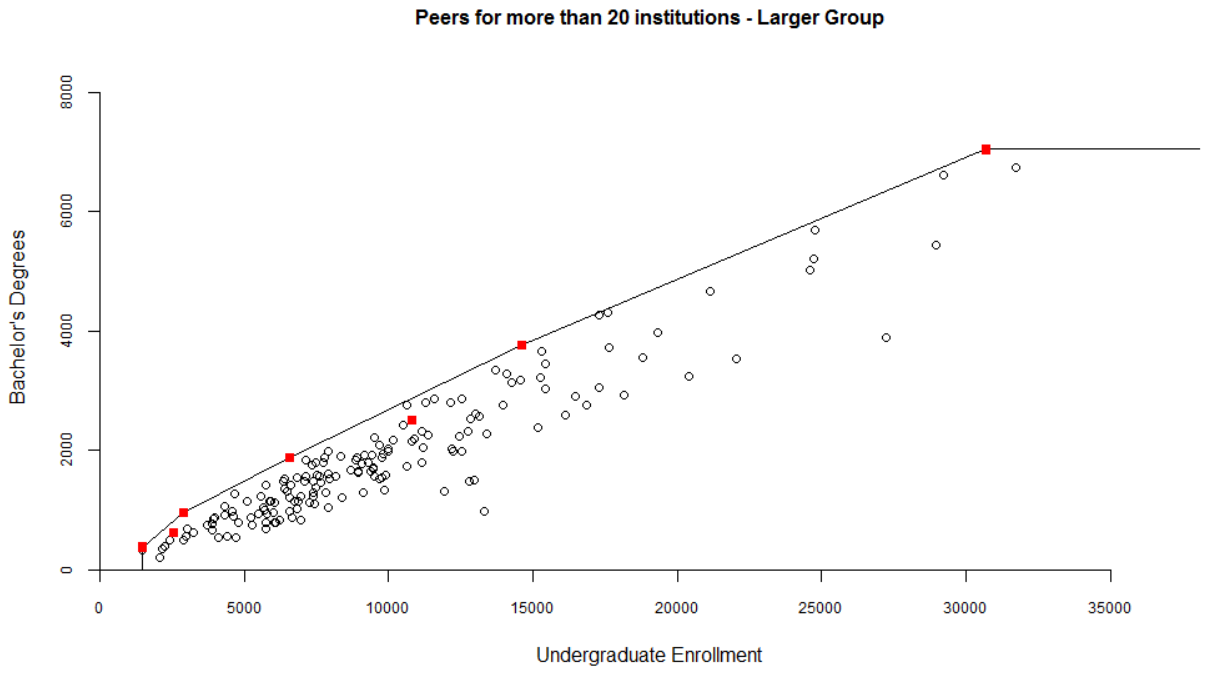


Figure 4. Identification of peers in the larger institution group that are peers for more than 20 institutions.

Determination of Slacks in Stage-One DEA Model

After peers were determined, slacks were calculated for each institution in each group of the study. Within a DEA model using an output orientation, slacks represent an on over-utilization of inputs (i.e., input slack) that can be reduced in order to achieve efficiency (Avkiran, 2001). The presence and amount of input slack can be determined for each input variable included in the DEA model. Table 9 shows descriptive statistics for the input slacks of the inefficient institutions in each group as the percentage of reduction for each input variable required for inefficient institutions to achieve efficiency within the construction of the DEA model used in this study. In general, institutions in the larger group could reduce the percentage of full-time equivalent academic staff by 15%, full-time equivalent administrative staff by 32%, revenues by 22%, and expenditures by 7% while producing the existing levels of output, as measured by the number of bachelor's degrees awarded. For the medium/smaller group, institutions could, on average, reduce the percentage of full-time equivalent academic staff by 22%, full-time equivalent administrative staff by 14%, revenues by 28%, and expenditures by 21% while maintaining the existing levels of output as measured by the number of bachelor's degrees awarded. There were no output slacks found for any institution included in this study. Appendices F and G include institution-level data pertaining to input slacks for each input variable included in the DEA model.

Table 9

Input Slacks for Inefficient Institutions by Institutional Group

	Mean	Standard Deviation	Median	Minimum	Maximum
Larger Group (*n*=152)					
undergraduates	0.35	1.67	0.00	0.00	10.22
academic_staff_FTE	15.15	11.35	13.91	0.00	42.42
admin_staff_FTE	31.76	24.62	33.91	0.00	87.12
revenues	21.97	18.17	21.77	0.00	68.06
expenditures	6.63	10.74	0.00	0.00	44.36
Medium/Smaller Group (*n*=82)					
undergraduates	1.14	4.72	0.00	0.00	29.90
academic_staff_FTE	22.17	12.38	23.80	0.00	46.12
admin_staff_FTE	13.84	19.61	0.00	0.00	81.06
revenues	27.64	22.64	26.94	0.00	82.47
expenditures	21.01	15.97	19.78	0.00	68.63

Institution-Level Data

In addition to the group-level statistics calculated through the stage-one DEA, institution-level data are provided for each institution included in this study. Appendices B and C provide three efficiency scores (VRS, CRS, SE) along with Returns to Scale values for each institution in the Master's medium/smaller group and larger group, respectively. Returns to scale is related to the impact of scale size on average production of outputs under efficient operation by a decision-making unit (DMU), as DMUs can exhibit increasing, decreasing, or constant returns to scale (Thanassoulis et al., 2008). Using the method proposed by Färe & Lovell (1985), returns to scale were calculated for each institution in this study. For the group of larger institutions, 50% (84 of 167) exhibited decreasing returns to scale; 43% (72 of 167) exhibited increasing returns to scale; and 7% (11 of 167) exhibited constant returns to scale. For the medium/smaller group of institutions, 81% (75 of 93) exhibited decreasing returns to scale; 16% (15 of 167) exhibited increasing returns to scale; and 3% (3 of 93) exhibited constant returns to scale. Decreasing

returns to scale serves as an indicator that institutions might benefit from reducing the scale of their operations (Agasisti & Johnes, 2009), while increasing returns to scale serves as an indication that institutions could, if feasible within their context, benefit from the expansion of the size of their operations, as increased input requirements would be off-set by increased output (Thanassoulis et al., 2008). Constant returns to scale occurs when DMUs are operating at both technical and scale efficiency, as 5% (14 of 270) of all institutions in this study exhibited constant returns to scale.

Research Questions and Results

Research Question 1: When compared to similar institutions nationally, how efficient are four-year public Master's universities in Arkansas at utilizing resources to achieve one of the mandatory measures (bachelor's degrees awarded) required by the new performance-funding program?

Table 10 provides institution-level data pertaining to the estimation of efficiency in the DEA procedure for the six Arkansas universities included in this study. All six institutions were operating near optimal levels of scale size, based on scale efficiency calculations above the 0.9 threshold on the 0-to-1 ratio scale. Although four institutions exhibited decreasing returns to scale, and two exhibited increasing returns to scale, the scale efficiency scores near 1.0 indicated each institution is operating at near optimal scale size and would only minimally benefit from an increase or decrease in scale size. These scale efficiency scores, when compared with the VRS efficiency scores, served as an indication that inefficiency is more so related to pure technical inefficiency at the institutional level as opposed to institutions exhibiting inefficiency based on the size of the institution.

Table 10

Results of DEA Model for Arkansas Institutions, 2011-2012 Academic Year

Institution[a]	VRS	CRS	SE	Returns to Scale[b]
Larger Group (*n*=167)				
ASU	0.664	0.664	1.000	drs[b]
ATU	0.600	0.599	0.997	irs
UCA	0.692	0.692	0.999	irs
Medium/Smaller Group (*n*=93)				
HSU	0.531	0.524	0.987	drs
SAU	0.515	0.492	0.956	drs
UAM	0.407	0.382	0.940	drs

[a]Abbreviations for Arkansas institutions: ASU-Arkansas State University Main Campus; ATU-Arkansas Tech University; UCA-University of Central Arkansas; HSU-Henderson State University; SAU-Southern Arkansas University Main Campus; and UAM-University of Arkansas at Monticello.
[b]ASU demonstrated decreasing returns to scale based on a CRS value of 0.6640, which was 0.0003 lower than the VRS value of 0.6643.

Table 11 provides input slack data for each of the six Arkansas universities included in this study. The bottom row of Table 11 shows the average percentage reduction for each input variable across all Arkansas institutions. Collectively, the Arkansas institutions had input slack of 24.78% for the full-time equivalent academic staff input variable, and 15.06% slack for the full-time equivalent administrative staff input variable. The Arkansas institutions had less than 10% slack for revenues (5.25%) and expenditures (4.35%), while demonstrating no input slack in the number of undergraduate students enrolled on campus. The individual institutional results will be discussed further below.

Table 11

Input Slacks for Inefficient Institutions, Arkansas Institutions

	Input Variables (%)				
Institution	x1	x2	x3	x4	x5
Larger Group (*n*=152)					
ASU	0.00	13.86	15.17	1.21	0.00
ATU	0.00	23.60	50.03	8.57	0.00
UCA	0.00	29.66	0.00	1.91	0.00
Medium/Smaller Group (*n*=82)					
HSU	0.00	27.20	0.00	16.84	14.26
SAU	0.00	32.63	2.45	2.99	0.00
UAM	0.00	21.76	22.72	0.00	11.81
Average for AR institutions	0.00	24.78	15.06	5.25	4.35

Input Variables: x1=undergraduates; x2=academic_staff_FTE; x3=admin_staff_FTE; x4=revenues; x5=expenditures

Individual Institutional Analyses

The following discussion will present results from the stage-one DEA analysis for each of the six Arkansas institutions independently, as the order of presentation is in descending order based on technical efficiency score for each Arkansas institution in the larger group and then the medium/smaller group.

Larger Institutions: University of Central Arkansas

The University of Central Arkansas (UCA) had a technical efficiency score of 0.69 on the output-oriented DEA model with the VRS assumption. This efficiency score can be interpreted as meaning that UCA could reduce the amount of each of the five inputs in the model by at least 31% while producing the same amount of output (number of bachelor's degrees). The peer institutions that serve as benchmarks for UCA included California State University-Chico, Fort Hays State University, State University of New York at New Paltz, and University of Houston-Victoria. The 31% reduction in the five original inputs served as the minimum amount needed

for UCA to produce its 1,619 bachelor's degrees efficiently given the type and levels of inputs included in the DEA model.

UCA's technical efficiency score was converted to a Farrell output technical efficiency estimate by taking the reciprocal of the Shephard-based efficiency estimate ($\frac{1}{0.69}$), which converted to a Farrell efficiency score of 1.45. From an output maximization perspective, UCA could increase its production of bachelor's degrees by as much as 45% [(Farrell efficiency score – 1)*100%] while keeping its existing inputs stable (Wolszczak-Derlacz & Parteka, 2011). If applied to the data in this study, a 45% increase in output would have raised the number bachelor's degrees awarded by UCA from 1,619 to 2,348 during the 2011-2012 academic year given the level of inputs included in the model. Based on the data in Table 11, UCA would need to reduce full-time equivalent academic staff by 29.66% and revenues by 1.91% in order for UCA to project to the efficiency frontier.

Larger Institutions: Arkansas State University

Arkansas State University-Main Campus (ASU) had an efficiency score of 0.66 in the DEA model. In order for ASU to reach the efficiency frontier based on the production of 1,687 bachelor's degrees in 2011-2012, the university would need to reduce each of the five inputs in the DEA model by 34%. The peer institutions identified for ASU through the DEA procedure included California State University-Chico, Fort Hays State University, and State University of New York at New Paltz. In order to determine what level of output production is possible for ASU at existing input levels during 2011-2012, the VRS efficiency estimate was converted to a Farrell technical efficiency score. The reciprocal of 0.66 equaled 1.52, indicating that ASU could produce 52% more bachelor's degrees given the existing types and levels of inputs included in the model. During 2011-2012, ASU awarded 1,687 bachelor's degrees, as a 52% increase in

output would represent 877 additional bachelor's degrees, which would bring the total to 2,564 bachelor's degrees, which represented the level of production required for ASU to be deemed efficient given its existing levels of inputs. A review of input slacks for ASU in Table 11 indicated the institution would need to reduce full-time academic staff by 13.85%, full-time equivalent administrative staff by 15.17%, and revenues by 1.21% in order to project to the efficiency frontier given existing output level.

Larger Institutions: Arkansas Tech University

Arkansas Tech University (ATU) had the lowest estimated efficiency score for the larger group institutions from Arkansas with a value of 0.6. ATU would need to reduce its five inputs included in the DEA model by 40% in order to reach the efficiency frontier occupied by its peer institutions, which included Fort Hays State University, State University of New York at New Paltz, and University of Houston-Victoria. From the perspective of increasing their output given existing inputs, ATU's Farrell technical efficiency score calculated from the reciprocal of the Shephard estimated efficiency score of 0.6 was 1.67, indicating a 67% increase in outputs possible while keeping inputs stable. This level of increase would be the equivalent of graduating an additional 813 students above the 1,214 awarded bachelor's degrees during 2011-2012. From an output maximization perspective, the 67% increase in bachelor's degrees to 2,027 would result in ATU reaching technical efficiency in relation to its weighted peers and residing on the efficiency frontier given existing levels of inputs. A review of input slacks for ATU in Table 11 indicated ATU would need to reduce full-time academic staff by 23.60%, full-time equivalent administrative staff by 50.03%, and revenues by 8.57% in order to project to the efficiency frontier given existing output level.

Medium/Smaller Institutions: Henderson State University

For the medium/smaller group institutions in Arkansas, Henderson State University (HSU) had the highest technical efficiency score of 0.53, which can also be interpreted indicating 47% inefficiency. In order for HSU to produce its existing level of output (507 bachelor's degrees awarded during the 2011-2012 academic year), HSU would need to reduce each of the five inputs in the DEA model by 47%. The combination of these decreases in inputs would place HSU on the efficiency frontier with their peer institutions: University of South Florida-Sarasota-Manatee, Metropolitan State University, and The Evergreen State College. Converting HSU's 0.53 estimated efficiency score to a Farrell output efficiency score resulted in a value of 1.89, indicating an 89% increase in bachelor's degrees could be produced with the existing input levels during 2011-2012. An 89% increase in bachelor's degrees would result in HSU graduating 451 more undergraduate students in addition to the 507 students that received degrees in 2011-2012, resulting in a projected total of 958 bachelor's degrees. A review of input slacks for HSU in Table 11 indicated the institution would need to reduce full-time academic staff by 27.20%, revenues by 16.84%, and expenditures by 14.26% in order to project to the efficiency frontier given existing output level.

Medium/Smaller Institutions: Southern Arkansas University

Southern Arkansas University (SAU) was just below HSU with a technical efficiency estimate of 0.52, which indicated an inefficiency level of 48% for the 2011-2012 academic year. Due to the proximity to HSU in the output-oriented model, SAU also had the same peer institutions: University of South Florida-Sarasota-Manatee, Metropolitan State University, and The Evergreen State College. SAU's Farrell technical efficiency score was 1.92, indicating that SAU could produce 92% more bachelor's degrees while maintaining input levels. A 92% increase in bachelor's degrees awarded would move SAU from awarding 406 diplomas to

undergraduates to 780 bachelor's degrees in 2011-2012. This increase of 374 students completing their undergraduate degree program would be required for SAU to be considered technically efficient given their existing levels of inputs included in the model. Input slacks for ATU in Table 11 indicated the institution would need to reduce full-time academic staff by 32.63%, full-time equivalent administrative staff by 2.45%, and revenues by 2.99% in order to project to the efficiency frontier given existing output level.

Medium/Smaller Institutions: University of Arkansas at Monticello

The University of Arkansas at Monticello (UAM) exhibited the lowest technical efficiency score of Arkansas institutions in the medium/smaller group at 0.407. With an efficiency score of 0.41, UAM would have to reduce its five inputs included in the DEA model by 59% in order to reach the efficiency frontier that is occupied by the same peer institutions as those of HSU and SAU: University of South Florida-Sarasota-Manatee, Metropolitan State University, and The Evergreen State College. From an output maximization approach, UAM's DEA estimated efficiency score of 0.407 was converted to a Farrell efficiency score of 2.46, which indicated UAM could increase its output of bachelor's degrees by 146% while maintaining the 2011-2012 level of inputs. A 146% increase would result in the original output of 380 bachelor's degrees in 2011-2012 for UAM growing to 935 bachelor's degrees being awarded. UAM's input slacks included in Table 11 indicated UAM would need to reduce full-time academic staff by 21..76%, full-time equivalent administrative staff by 22.72%, and expenditures by 11.81% in order to project to the efficiency frontier given existing output level.

In summary, the Arkansas Master's universities included in this study were inefficient in the production of bachelor's degrees awarded in 2011-2012, given the inputs included in the

DEA model and in relation to the near population-level national sample of Master's Colleges and Universities included in this study.

Research Question 2: Which environmental factors contribute to the estimated efficiency of the inefficient four-year public Master's Colleges and Universities included in this study?

In the second stage of the analytical technique used in this study, DEA efficiency estimates produced in stage one were regressed on five environmental variables using Simar and Wilson's (2007) Algorithm #2 double bootstrap truncated regression approach. This technique overcomes the inherent non-statistical nature of DEA methodologies while also accounting for serial correlation stemming from the relative nature of finite samples in DEA models, as well as the correlation between the estimated efficiency scores determined in stage one and the environmental variables used in the stage two procedure (Simar & Wilson, 2007). The bootstrap method also corrects for bias existing in the DEA estimates and provides for constructing more precise confidence intervals used in statistical inferences (Haug & Blackburn, 2013). The regression model can be expressed as:

$$\hat{\hat{\theta}}_i = \beta_0 + \beta_1 net\_tuition_i + \beta_2 perf\_fund_i + \beta_3 GDP_i + \beta_4 share_i + \beta_5 attainment_i + \varepsilon_i$$

where $\hat{\hat{\theta}}_i$ is the bootstrapped bias-corrected efficiency score; *net_tuition* refers to the net tuition share of operating revenues; *perf_fund* is a dichotomous variable indicating the existence of an active state performance-funding program during 2012; *GDP* refers to the state's per capita real gross domestic product; *share* is higher education's share as a percentage of state's total expenditures; and *attainment* is the percentage of the state's population (25-34 years old) with a bachelor's degree or higher. In order to aid in meaningful interpretation of the results of the truncated regression analysis, *GDP* was rescaled by a value of $1,000.

Based on the guidelines in Simar and Wilson's (2007) Algorithm #2, the institutions included in the second-stage truncated regression analysis were the inefficient institutions with an original DEA estimated efficiency score < 1.0. As such, this portion of the analysis included 82 (out of 93) medium/smaller institutions and 152 (out of 167) larger institutions that exhibited technical inefficiency with a VRS score < 1.0. Table 12 shows the bias-corrected coefficients with 95% bootstrapped confidence intervals for the inefficient institutions in each institution group. A positive sign in front of the bias-corrected coefficient indicates that, *ceteris paribus*, a one-unit increase in the corresponding variable will increase efficiency, while a negative sign in front of the bias-corrected coefficient indicates that, with the other variables held constant, a one-unit increase in the corresponding variable will decrease estimated efficiency. Statistical significance of the bias-corrected coefficient was determined by whether the value of zero fell within the confidence interval corresponding to the coefficient under consideration.

Table 12

Determinants of Estimated Efficiency Scores for Inefficient Institutions by Group

	Medium/Smaller Group (*n*=82)			Larger Group (*n*=152)		
	Bias-corrected	95% Bootstrap confidence intervals		Bias-corrected	95% Bootstrap confidence intervals	
Variables	coefficients	Low	High	coefficients	Low	High
net_tuition	0.0022	-0.0001	0.0039	0.0021*	0.0004	0.0032
perf_fund	-0.0096	-0.0708	0.0523	0.0053	-0.0355	0.0045
GDP	0.0075*	0.0019	0.0120	0.0090*	0.0045	0.0117
Share	-0.0077*	-0.0127	-0.0006	-0.0014	-0.0044	0.0023
attainment	0.0035	-0.0038	0.0010	-0.0024	-0.0069	0.0025

* Value of zero does not fall within 95% confidence interval.
Constants are not reported. Results based on 2,000 replications in double bootstrap procedure.

As presented in Table 12, two environmental factors were statistically significant for each group of institutions, albeit not the same two variables in each group. For both groups, the state's per capita real gross domestic product (GDP) was associated with an increase in efficiency at a statistically significant level. In the medium/smaller group, a $1,000 increase in GDP would

result in a 0.75 percentage point increase in estimated efficiency, while a $1,000 increase in GDP would result in a 0.90 percentage point increase in estimated efficiency for the inefficient institutions in the larger group included in this study.

The other variable that was significant in the medium/smaller group was higher education's share of the state's total expenditures (*share*), as a one percentage point increase in share would result in a 0.77 percentage point decrease in institutional efficiency. While not statistically significant, share was also found to have a negative impact on efficiency in the larger group as well. For the larger group institutions, the other significant variable was the share of operating revenues based on net tuition, as a one percentage point increase in net tuition would result in a 0.21 percentage point increase in estimated efficiency. For the medium/smaller group, net tuition was also positively associated with increased efficiency, although not at a statistically significant level.

Given that the 95% confidence interval values for the statistically significant environmental variables were so close to zero, additional analyses were conducted to confirm the existence of statistically significant findings. The robustness of these findings was tested by re-running the double bootstrap truncated regression procedure with 10,000 replications for each group. The findings of statistical significance for the variables held when increasing the bootstrap replications from the original 2,000 to 10,000 replications as part of the robustness checking process. This supports the statistically significant findings for the four variables across groups that were included in Table 12.

Based on the results of the second-stage truncated regression analysis, the environmental variables that were statistically significant determinants of estimated efficiency scores in the medium/smaller group were *GDP* (positive association) and higher education's *share* of total

state appropriations (negative association), while *GDP* and *net_tuition* share of overall revenues were both positively associated in the larger group of institutions.

Research Question 3: Does the existence of a performance-funding program impact the estimated institutional efficiency of the four-year public Master's Colleges and Universities included in this study?

During the 2011-2012 academic year, 12 of the 41 states that were represented in this study had a performance-funding program in place (Gorbunov, 2013). A dichotomous variable was included in the truncated regression model that indicated the existence of a performance-funding program, as 35% (33 of 93) of institutions in the medium/smaller group and 29% (49 of 167) of institutions in the larger group had a value of 1 for performance funding in the overall analysis. Based on the results in Table 12, the existence of performance funding was not a significant factor related to estimated efficiency for either the medium/smaller or larger group of institutions. Interestingly, the signs in front of the bias-corrected coefficient for performance funding were opposite between groups (-0.0096 for medium/smaller institutions and 0.0053 for larger institutions). For the medium/smaller institutions, holding other variables constant, the existence of a performance-funding program decreased efficiency by 0.96 percentage points, while the existence of performance funding increased efficiency by 0.53 percentage points for larger institutions. Possible reasons for this discrepancy between the groups on the performance funding variable will be explored in the discussion section of Chapter 5.

Therefore, the existence of a performance-funding program did not have an impact on the estimated institutional efficiency of the Master's Colleges and Universities included in this study.

Research Question 4: What are the policy implications related to institutional efficiency within Arkansas' performance-funding program?

The current performance-funding program in Arkansas is comprised of a variety of mandatory and optional measures that can be used to determine whether public colleges and universities have performed sufficiently to be awarded the portion of base funding directly tied to performance outcomes. For the public four-year institutions in Arkansas, the mandatory measures consist of the number of bachelor's degree credentials awarded, the total number of credentials awarded, the number of STEM credentials awarded, and a percentage-based progression measure. However, missing within the implemented performance-funding system is a measure related to how efficiently public institutions of higher education in Arkansas are converting inputs into outputs. Within the current context of higher education, which includes greater levels of institutional privatization as universities seek to off-set proportionally decreasing state support, institutions are being asked to generate higher levels of output (degrees and credentials) within existing, if not decreasing, fiscal constraints. Therefore, how efficiently institutions are creating outputs from inputs should be a point of consideration for policymakers, institutions, taxpayers, parents, and students alike.

One policy implication stemming from this research was the creation of an efficiency measure based on an analytical technique that could be incorporated directly into the existing mandatory measures used in the performance-funding program. The efficiency estimates calculated in this research were based on nearly the entire population of public Master's Colleges and Universities in the United States. Given that DEA-based efficiency estimates are calculated in relative terms to other decision-making units in the data, having a national sample of almost

98% of all larger Master's universities and almost 94% of all medium/smaller Master's universities adds reliability to the results of the DEA findings of this study.

The straightforward interpretation of DEA efficiency estimates provides a meaningful measure of efficiency that can easily be communicated to a variety of stakeholders. Because the technical efficiency scores calculated in this study were on a 0 to 1 ratio scale, the scores can be interpreted directly as a percentage of efficiency in converting the inputs into outputs that were included in the model. If the same model, including inputs, outputs, and institutions, was updated annually with new data, the percentage of efficiency for each institution could be tracked across years to determine whether institutional efficiency was improving, static, or declining over time. Using this process would follow the existing structure of Arkansas's performance-funding system that compares institutional performance from year-to-year in order to award funding based on a comparison of that institution's previous performance, as opposed to inter-institutional comparisons of performance.

An additional policy implication of this study's findings was the determination of peer institutions for each of the Arkansas Master's universities included in the study. These peer institutions were deemed to be operating efficiently in producing bachelor's degrees using the combination of input variables included in the DEA model. The identification of efficiently operating peer institutions provides administrators at inefficient universities with a set of institutions from which to learn. For example, the three Arkansas institutions in the medium/smaller group (Henderson State University, Southern Arkansas University, and University of Arkansas at Monticello) had the same three peers: University of South Florida-Sarasota-Manatee, Metropolitan State University, and The Evergreen State College. On average, the three efficient peer institutions produced 177% more bachelor's degrees (1,192 versus 431)

than the three Arkansas institutions during the 2011-2012 academic year. The peer institutions had higher levels on four input variables than the Arkansas universities: 38% more undergraduates (4302 versus 3109); 52% more full-time equivalent administrators (47 versus 31); 83% more revenue ($34.8 million versus $19 million); and 39% more in expenditures ($56.9 million versus $41 million). On the fifth input, full-time equivalent academic staff, the three peer institutions actually had an average of 2% fewer personnel (182 versus 186) than the Arkansas institutions. Based on an average difference, the efficient peer institutions produced 177% more outputs with just over 42% more inputs. The capacity of the DEA-based analytical technique to specifically identify efficiently operating peer institutions carries with it the implication that institutional administrators can consult with these peers to determine ways in which the inefficient institution can improve.

There are also implications associated with the conceptual framework utilized in this study, as agency theory served as the policy lens through which the performance-funding program in Arkansas was reviewed. At its most basic level, agency theory posits that the existence of a contractual relationship between a principal and an agent creates an agency problem that stems from two primary constructs that are beneficial to the agent: informational asymmetries and goal conflicts. Informational asymmetries are caused by the agent having better, more complete, and oftentimes specialized information that is "hidden" from the principal (Pratt et al., 1985). Goal conflicts arise when the agent chooses to "shirk" job-related responsibilities due to being a self-interested, utility maximizer who seeks personal goals and objectives at the expense of the goals and objectives of the principal (Eisenhardt, 1989; Lane, 2012; Moe, 1984; Pratt et al., 1985). In agency theory, the measures the principal takes to monitor the activities of the agent are essentially attempts to decrease informational asymmetry

by requiring agents to provide information that may otherwise not be accessible to the principal, which also serves as a mechanisms for aligning the goals of the agent with those of the principal (Kivistö, 2007).

The existing performance-funding program in Arkansas can be described in terms of the state (principal) entering into a contractual relationship with institutions of higher education (agents) to produce outputs that will achieve the goals established by the state (more citizens with post-secondary degrees and credentials). Through the inclusion of annual performance measures that are tied to an increasing proportion of base funding, the state of Arkansas has attempted to reduce the informational asymmetries that exist between it and the public institutions in the state. With the percentage of base funding tied to performance increasing to 25% in 2017-2018, the state's policy construction can be explained by agency theory in terms of the state coercing/incentivizing colleges and universities to align their institutional goals, priorities and actions with those of the state. Through the combination of monitoring performance on specified outcomes and tying funding to the achievement of those outcomes, the state of Arkansas has attempted to mitigate the potential for institutions to shirk their perceived responsibilities of ensuring a well-educated citizenry that contributes to the workforce and economic development efforts of the state.

Eisenhardt (1989) posited that principals had two options when determining the mechanisms to be used in overcoming the agency problem within a contractual relationship with an agent: behavior-based contracts and outcome-based contracts. Table 13 provides the taxonomy that Eisenhardt (1989) originally developed and was slightly modified by Lassar and Kerr (1996). Applying the components of this taxonomy to the existing policy in Arkansas, it is

apparent that the outcome-based contract created by the performance-funding program has merit from a conceptual perspective:

- Given the complexities, specialization, and hierarchical nature of institutions of higher education, high levels of informational asymmetries typically exist, making it difficult for information systems at the state level to comprehensively capture all of the relevant information needed to overcome the agency problem.
- Due to the typical stability of institutions of higher education coupled with the multi-year time frame for increasing certain types of outcomes, there is a fairly low level of outcome uncertainty involved in the performance-funding program.
- With 25% of base funding being tied to performance outcomes within the next four years, the aversion to risk is increasing for colleges and universities, meaning that the principal can pass some of the risk associated with funding allocations for higher education to the institutions by imposing outcome-based contractual agreements.
- At the heart of agency theory is goal conflict. In the relationship between states and institutions of higher education, not only are institutional goals sometimes at odds with state goals, but individual faculty/staff goals may be at odds with both the institutional and state goals passed down through hierarchical chains of command.
- Due to the specialized nature of teaching and research, there is a very limited opportunity for the state to use task programmability as means for ensuring agents' actions promote the goals and objectives of the principal.
- Within the new performance-funding program in Arkansas, there is a high level of outcome measurability, as four specific mandatory measures have been delineating, as well as 10 optional measures have been clearly defined.

- Within this taxonomy, the length of the relationship between the state and its public institutions of higher education seems to be the only variable in which a behavior-based contract would be more efficient.

Table 13

Variables affecting the efficiency of behavior-oriented vs. outcome-oriented contracts

	Behavior-based contract is efficient when:	Outcome-based contract is efficient when:
Information systems	High	Low
Outcome uncertainty	High	Low
Risk aversion	Agent	Principal
Goal conflict	Low	High
Task programmability	High	Low
Outcome measurability	Low	High
Length of Relationship	Long	Short

Sources: Eisenhardt (1989) and Lassar & Kerr (1996)

Given the results of the analytical analysis and the application of agency theory as the conceptual framework used in this study, the policy implications stemming from this research include the following: the provision of a measure of efficiency that can be incorporated directly into the existing performance-funding program; the creation of a list of peer institutions for each Arkansas Master's university from which to consult and learn; and agency theory, especially through the lens of Eisenhardt's (1989) taxonomy, was a viable conceptual framework for understanding why the state of Arkansas adopted performance-funding policy for the fourth time in 20 years.

Chapter Summary

This study sought to examine the institutional efficiency of public four-year Master's universities in Arkansas in comparison to a national population of similarly classified institutions. Data were collected through publicly available sources, primarily the Integrated Post-secondary Education Data System (IPEDS). Based on an initial analysis of descriptive

statistics, the Master's programs classified as medium and smaller by the Carnegie Foundation were collapsed into a single group, while the larger Master's colleges and universities served as a second group. Due to missing data, the full population of 270 four-year, public Master's institutions (171 larger and 99 medium/smaller) was reduced to 167 larger and 93 medium/smaller institutions that were grouped separately for the analyses conducted in the study. The Arkansas institutions in the medium/smaller group were Henderson State University, Southern Arkansas University, and University of Arkansas at Monticello. The larger group institutions in Arkansas included Arkansas State University, Arkansas Tech University, and University of Central Arkansas.

The analytical technique used to answer directly three of the research questions included in this study was the double bootstrap truncated regression procedure specified as Algorithm #2 by Simar and Wilson (2007). In general, the procedure involved the calculation of bias-corrected technical efficiency scores with 95% confidence intervals in stage one, and the regressing of bias-corrected technical efficiency scores on environmental variables in stage two of the procedure. The original efficiency estimates in Step 1 of Algorithm #2 were constructed using data envelopment analysis (DEA). Technical efficiency (TE) scores were calculated using an output-oriented model under the assumption of variable returns to scale (VRS), as additional efficiency estimates were calculated under the constant returns to scale (CRS) to facilitate the decomposition of efficiency into pure technical efficiency and scale efficiency (SE).

In response to research question #1 related to the estimated efficiency of Arkansas's Master's universities, the six Arkansas institutions all demonstrated high levels of scale efficiency, with SE scores above 0.94, which means that the greatest portion of technical inefficiency was caused by pure technical inefficiency, not the size or scale of institutional

operations. The three larger group institutions in Arkansas had TE scores under the VRS assumption ranging from 0.600 (ATU) to 0.664 (ASU) to 0.692 (UCA). In the medium/smaller group, the Arkansas institutions had TE scores ranging from 0.531 (HSU) to 0.515 (SAU) to 0.407 (UAM). Based on input slacks, the Arkansas institutions would need to, on average, reduce full-time equivalent academic staff by 24.78%, full-time equivalent administrative staff by 15.06%, revenues by 5.25%, and expenditures by 4.35% in order to project to the efficiency frontier given existing levels of output.

The second and third research questions were answered through Simar and Wilson's (2007) double bootstrap truncated regression procedure that sought to address determinants of technical inefficiency in the inefficient institutions in each group. For the medium/smaller institution group, two environmental variables were found to be statistically significant at the .05 level: the state's per capita real gross domestic product (GDP) and higher education's share of state's total expenditures (share). GDP was positively associated with technical efficiency while share was negatively associated with technical efficiency. For the larger institution group, GDP was also a positive, statistically significant factor at the .05 level, while net tuition share of institutional revenues was positive and statistically significant for the larger group of institutions. The existence of a performance-funding program was not a statistically significant determinant of estimated efficiency, although this variable had a negative effect on efficiency estimation for the medium/smaller group while having a positive effect on efficiency in the larger group of institutions, with the other variables held constant in the regression model.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

For the fourth time in the past 20 years, the state of Arkansas has implemented a performance-funding program for its public institutions of higher education. Act 1203 of 2011 was signed into law by Governor Mike Beebe on April 5, 2011. This legislation was distinguished from previous policy efforts in that it shifted funding based on performance from being a bonus above base funding to being included in the amount of base funding allocated to institutions. The 2013-14 academic year served as the initial year of the five-year implementation process in which the percentage of funding tied to performance outcomes will increase incrementally by 5% each year until 2017-18, at which point 25% of base funding will be allocated on the basis of institutions demonstrating successful achievement of a variety of outcome measures.

This new performance-funding program was developed, in part, as a response to Governor Beebe's challenge issued during his State of the State Address in 2011, in which he charged, "We can and must double the number of college graduates in Arkansas by 2025 if we are to stay competitive. This is a lofty goal aimed at the future, but we must begin implementing it today" (ADHE, 2011, p. 2). Based on the U.S. Census Bureau's 2011 American Community Survey results, Arkansas ranked 48th in the country in the percentage of 25 to 64 year-old adults with a bachelor's degree or higher at 21.6%, and ranked 47th with 22.7% of 25 to 34 year-old adults with a bachelor's degree or higher (NCHEMS, Retrieved from http://www.higheredinfo.org/). For Arkansas to achieve Beebe's established goal, Arkansas institutions of higher education would need to increase the number of post-secondary credentials

(bachelor's degrees, associate degrees, and certificates) awarded annually from 17,200 in 2011 to 34,400 in 2025 (NCHEMS, 2011).

The latest iteration of performance-funding policy in Arkansas provided the context in which this study was conducted. While numerous mandatory and optional measures have been specified in program documentation, a gap exists from the standpoint that no specific measure holding institutions accountable for the efficient use of resources was included in the implemented performance-funding program (ADHE, 2011). This omission from the implemented policy is interesting from the perspective that the very title of the legislation includes the words, "An Act to Promote Accountability and Efficiency at State-Supported Institutions of Higher Education" (Act 1203 of 2011). This study filled the gap by providing a measure of efficiency that can be implemented within the existing performance-funding program.

This chapter focuses on the findings of this study and the delineation of a set of conclusions that can inform future policy practice and policy research. This chapter begins with a summary of the study, which is followed by a brief discussion of findings with clarifying points, the explication of conclusions and limitations, as well as future policy and research recommendations. The chapter ends with a brief summary.

Summary of the Study

The purpose of this quantitative study was to estimate the efficiency of four-year public Master's universities in Arkansas in achieving one of the mandatory outcomes specified in the state's performance-funding program: number of bachelor's degrees awarded. This study also utilized agency theory as a conceptual framework to explore the contractual relationship between Arkansas and its public institutions of higher education within the latest iteration of performance

funding. This study is significant in that the results of the analytical technique, specifically the technical efficiency estimates, could be directly incorporated into the existing performance-funding program, which fills a gap between the designed policy and the implemented policy. In the larger context of higher education literature, this is one of the few studies that has specifically examined the efficiency of institutions that are categorized as Master's Colleges and Universities by the Carnegie Foundation. This study is also significant from the perspective of explicating, through the lens of agency theory, possible reasons for the state's adoption of a performance-funding program for the fourth time in less than 20 years. Four primary research questions guided this study:

1. When compared to similar institutions nationally, how efficient are four-year public Master's universities in Arkansas at utilizing resources to achieve one of the mandatory measures (bachelor's degrees awarded) required by the new performance-funding program?
2. Which environmental factors contribute to the estimated efficiency of the inefficient four-year public Master's Colleges and Universities included in this study?
3. Does the existence of a performance funding program impact the estimated institutional efficiency of the four-year public Master's Colleges and Universities included in this study?
4. What are the policy implications related to institutional efficiency within Arkansas' performance-funding program?

In order to answer these research questions, data were collected from a variety of publicly available sources. The primary data collection occurred through the Integrated Post-secondary Education Data System (IPEDS) web portal (http://nces.ed.gov/ipeds/). Four other sources

provided specific data points that served as variables in this study: the National Center for Higher Education Management Systems (NCHEMS) Information Center (http://www.higheredinfo.org/); the U.S. Department of Commerce's Bureau of Economic Analysis (http://www.bea.gov/regional/index.htm); Gorbunov (2013); and the National Association of State Budget Officers (NASBO, 2013). Data were collected for the 2011-2012 academic year, which is the most recent year that data for a number of financial variables was available through these data sources.

The population of interest in this study was public four-year Master's Colleges and Universities in the United States. These institutions face a variety of challenges, including "mission creep" (Gonzales, 2012, p. 338) that has conflated the institutional identity unique to comprehensive institutions; greater privatization of higher education funding streams due to reduced state support; and increased percentages of students from underrepresented populations and students who are academically underprepared (Wright et al., 2004). The total population of four-year public Master's Colleges and Universities in the United States was 270 institutions, which included 171 larger programs, 61 medium programs, and 38 smaller programs, as these sub-categories are based on the number of master's degrees awarded during the Carnegie reclassification year combined with fewer than 20 research doctorates awarded in that year (Carnegie Foundation for the Advancement of Teaching, 2014). In Arkansas, three institutions are classified as larger programs (Arkansas State University-Main Campus (ASU), Arkansas Tech University (ATU), and University of Central Arkansas(UCA)), two are considered medium programs (Henderson State University (HSU) and Southern Arkansas University-Main Campus (SAU)), and one is classified as a smaller program (University of Arkansas at Monticello (UAM)). Based on an initial analysis of descriptive statistics related to these three categorical

groupings, it was determined that the medium and smaller institutions were more homogenous than dissimilar, so they were collapsed into a single group. Due to missing data, the final sample used throughout this study consisted of 167 larger institutions and 93 medium/smaller institutions.

Agency theory was utilized as the conceptual framework through which the existence of a fourth iteration of performance funding in Arkansas was examined. Agency theory posits that within a contractual relationship, the principal abdicates certain decision-making responsibilities to the agent, creating the potential for the *agency problem* to exist (Moe, 1984). This agency problem is primarily comprised of two co-existing constructs: informational asymmetries and goal conflicts. Informational asymmetry occurs when the agent knows more about his or her own abilities, expertise, and honesty than the principal, as Shapiro (2005) contended that an agent "sometimes makes matters worse by exaggerating talents" (p. 263). Goal conflicts occur when the interests and desires of the principal and agent are misaligned (Kivistö, 2005). The combination of informational asymmetries and goal conflicts provide an opportunity for agents to shirk their contractual responsibilities, which is the essence of the agency problem addressed by agency theory (Waterman & Meier, 1998). Through the lens of agency theory, this study posited that the state of Arkansas used its newest performance-funding policy and program as a means for coercing and incentivizing the alignment of goals and actions by public institutions of higher education with the goals and objectives of the state. The policy lever consisted of linking a percentage of base funding to the demonstration of performance on a variety of measures. Once fully implemented in 2017-2018, 25% of institutional base funding from the state will be directly tied to increasing performance on the mandatory and optional measures outlined in the performance-funding program.

The analytical technique utilized in this study was Simar and Wilson's (2007) Algorithm #2 double bootstrap truncated regression analysis. The base methodology in this technique is data envelopment analysis (DEA), which provides a means for estimating the efficiency of decision-making units (DMUs) by comparing the inputs and outputs in the data and calculating an efficiency estimate relative to the DMUs included in the data set. In its base form, DEA is a non-parametric, non-statistical methodology that suffers from the inability to make statistical inferences of DEA estimates directly. The bootstrapping procedures used by Simar and Wilson overcoming this deficiency through numerous replications of the data, from which statistical inferences, including 95% confidence intervals, can be constructed. The base DEA technique also fails to identify which specific variables serve as determinants of technical efficiency as determined through DEA. The second-stage truncated regression approach, in which bias-corrected efficiency estimates are regressed on environmental variables in Simar and Wilson's Algorithm #2, provides a means for examining which variables contribute most to the efficiency (inefficiency) of institutions in the data set. Coupling bootstrapping with truncated regression also increases the accuracy of the confidence intervals constructed around the coefficients determined through the truncated regression procedure.

Conclusions

Conclusion #1: The six public Master's universities in Arkansas were inefficient in producing bachelor's degrees given the inputs included in this study and in comparison to an almost complete sample of the national population of institutions in the same Carnegie classifications during the 2011-2012 academic year.

Through the analyses conducted, each of the six Arkansas institutions included in this study received a technical efficiency score based on an output-oriented model under the

assumption of variable returns to scale (VRS). Institutions with an estimated efficiency score of 1.0 are considered technically efficient, while institutions with an estimated efficiency score < 1.0 are considered technically inefficient. Institutions exhibiting technical efficiency comprise the efficiency frontier against which inefficient institutions are measured. Subtracting the technical efficiency score from 1.0 provides a measure of proportional decrease in inputs an institution would have to make in order to reside on the efficiency frontier given existing output.

All six Arkansas institutions exhibited technical inefficiency with scores < 1.0. In the larger group, UCA had the highest technical efficiency score of the Arkansas institutions at 0.692, as ASU's efficiency estimate was 0.664 and ATU's efficiency score was 0.600. UCA would have to reduce each of the five inputs in the model by almost 31%, while ASU would need to reduce inputs by over 33% and ATU by 40% in order to reach the efficiency frontier. For the medium/smaller group, HSU had an efficiency score of 0.531, which indicated that HSU would need to reduce each input by almost 47% in order to produce the same number of bachelor's degrees efficiently in comparison to the efficient peer institutions residing on the efficiency frontier. SAU had a technical efficiency score of 0.515, indicating an almost 49% reduction in inputs would be required to obtain efficiency in producing bachelor's degrees at the same level. UAM would need to reduce input levels by almost 60%, based on a technical efficiency score of 0.407, in order to produce efficiently the same number of bachelor's degrees as were awarded in 2011-2012.

Conclusion #2: The six public Master's universities in Arkansas were operating at near optimal scale size during the 2011-2012 academic year.

By conducting a DEA model based on the assumption of variable returns to scale (VRS), technical efficiency scores were decomposed into pure technical efficiency and scale efficiency.

Scale efficiency serves as an indicator of the extent to which scale size impacts institutional efficiency. The scale efficiency scores for each Arkansas institution were 1.000 for ASU, 0.999 for UCA, 0.997 for ATU, 0.987 for HSU, 0.956 for SAU, and 0.940 for UAM. The high scale efficiency scores of the Arkansas institutions included in this study support the conclusion that each institution is operating at near optimal scale size given the inputs and output measures, and in relation to the other institutions included in this study.

Conclusion #3: The state's per capita gross domestic product (GDP) was a positive, significant predictor of technical efficiency in the two groups of Master's Colleges and Universities included in this study.

The results of the second-stage truncated regression analysis indicated that the bias-corrected coefficient for state GDP was positive and statistically significant for each group of institutions, as the value of zero did not fall within the 95% bootstrapped confidence interval constructed for the GDP coefficient. In the medium/smaller group, the GDP coefficient of 0.0075 can be interpreted as meaning a $1,000 increase in the state's GDP would increase technical efficiency of institutions in that group by 0.75 percentage points, with the other variables in the model held constant. For the larger group of institutions, the 0.0090 coefficient represented a 0.90 percentage point increase for every $1,000 increase in state-level GDP. The significant finding related to the impact of state GDP on institutional efficiency has been found in other research in which GDP has been conceptualized as an environmental variable that can be beneficial to universities due to "spillover" effects stemming from an institution's location (Kempkes & Pohl, 2010, p. 2069).

Conclusion #4: The percentage of the state's total expenditures dedicated to higher education was negatively associated with technical efficiency in both groups in the study, and was statistically significant in the medium/smaller group.

With higher education's share of total state expenditures having fallen from a peak of 17% in 1986 to 9.9% in 2013 (NASBO, 1997, 2013; Tandberg, 2010b), the second-stage truncated regression analysis included the percentage of the state's total expenditures on higher education (*share)* as one of the five environmental variables included in the model. The regression results indicated that the share of state appropriations had a negative impact on technical efficiency for both groups, but at a statistically significant level for the medium/smaller group in the analysis based on the value of zero not falling within the 95% confidence interval constructed for the *share* coefficient. The bias-corrected coefficient for the *share* variable was -0.0077 for the medium/smaller group, meaning a 1% increase in the share of state appropriations allocated to higher education would reduce the efficiency of medium/smaller institutions by 0.77 percentage points. While not a significant determinant of technical efficiency, the *share* coefficient was negative for the larger group as well (-0.0014), indicating a 1% increase in higher education's share of state appropriations would result in a 0.14 percentage point reduction in technical efficiency for the institutions in the larger group.

Conclusion #5: The percentage of an institution's revenue generated through net tuition was positively associated with technical efficiency in both groups in the study, and was statistically significant in the larger group.

Due to the decreasing proportion of state support for higher education, colleges and universities have been seeking ways to off-set losses of state appropriations by privatizing funding streams through non-state sources such as student tuition and fees, contracts for services

and grants, and private donations (Whitney, 2006; Zemsky et al., 1997; Zumeta, 2004). To account for the potential impact of privatization on institutional efficiency, the net tuition (*net_tuition*) variable was included in the second-stage truncated regression model as a share of operating revenues based on net tuition received. For both groups in this study, the *net_tuition* coefficient was positive. For the larger group, *net_tuition* was statistically significant with a value of 0.0021, indicating that a 1% increase in the share of net tuition would result in a 0.21 percentage point increase in institutional efficiency, while holding the other variables constant. While not statistically significant in the medium/smaller group, the coefficient was actually higher at 0.0022, as a 1% increase in *net_tuition* would result in a 0.22 percentage point increase in institutional efficiency for this group, holding other variables constant.

Conclusion #6: Performance funding was not a significant determinant of technical efficiency in the two groups of Master's Colleges and Universities included in this study.

The policy environment for this study was the state of Arkansas's fourth adoption of a performance-funding program in 2011. In the second-stage regression analysis, a dichotomous variable indicating whether a performance-funding program was in existence during 2011-2012 was included as an environmental variable. The existence of performance funding was found to not be a significant determinant of estimated efficiency in either group included in this study. In the medium/smaller group, the *perf_fund* coefficient was -0.0096, indicating that institutions within states with a performance-funding program had an estimated efficiency score that was 0.96 percentage points lower than institutions not residing in a state with a performance-funding program. However, for the larger group, the sign in front of the performance-funding coefficient was flipped (0.0053), as larger Master's institutions residing in states with performance funding had an efficiency score that was 0.53 percentage points higher than institutions located in states

without a performance-funding program. The combination of non-significance in the model and flipped signs before the coefficient for each group is consistent with previous research that has failed to find significant impacts of performance-funding programs across a variety of research domains (Archibald & Feldman, 2008; Dougherty & Reddy, 2013; Liefner, 2003; McLendon et al., 2006, 2005; Rabovsky, 2012; Sanford & Hunter, 2011; Sav, 2012; Shin, 2010; Tandberg & Hillman, 2014; Volkwein & Tandberg, 2008).

Conclusion #7: Agency theory provided a viable conceptual framework for exploring the fourth-generation adoption of a performance-funding program by the state of Arkansas in 2011.

Viewed through the lens of agency theory, the performance-funding program in Arkansas can be conceptualized as a contract between the state and its public institutions, who are tasked with increasing performance in exchange for a percentage of base state funding. With Arkansas ranked in the bottom 10% of all states in the percentage of adults with a bachelor's degree or higher nationally (NCHEMS, Retrieved from http://www.higheredinfo.org/), the performance-funding program can be viewed as the state attempting to coerce, through financial incentives, increased outputs by universities to meet the workforce and economic development demands of the state. The assumptions and tenets of agency theory, which seek to explain the mechanisms principals use to overcome agency problem, served as a viable framework through which to explain why the state of Arkansas adopted a performance-funding program for the fourth time in the past 20 years.

Limitations

Several limitations existed in this study. Due to missing data, the analyzed sample of Master's Colleges and Universities was reduced by 2.3% of larger institutions and 6.1% of medium/smaller institutions, resulting in national samples that included 167 larger and 93

medium/smaller institutions. The use of a national sample, while increasing the robustness of the data, provided an additional limitation in this study: time-lagged data. Because the most recent financial data available in IPEDS were from the 2011-2012 academic year, the results of this study is limiting from the standpoint of policymakers and institutional decision-makers having more recent data that can be used within decision-making processes. An additional limitation related to the analytical methodology used in this study was the lack of generalizability of efficiency estimates. Data envelopment analysis is a non-parametric, deterministic approach that relies strictly on the data included in model. Therefore, the addition or removal of data points or decision-making units from the analysis has the potential to impact which institutions are found efficient and those that are inefficient. Another limitation was the use of a single output variable in the stage-one DEA model, a limitation that was due primarily to data availability.

Recommendations for Future Practice and Research

The results of estimating the efficiency of public four-year Master's universities in Arkansas could be incorporated into the existing performance-funding program as an additional mandatory measure. Results from the 2011-2012 academic year included in this study could serve as a baseline for the Master's institutions, while the technique could be utilized to calculate efficiency estimates for the other public four-year institutions in Arkansas that were not included in this study. With a baseline established, the same technique, consisting of the same inputs, outputs, and institutions, could be applied on an annual basis to update technical efficiency of each institution in order to make comparisons to previous years in order to determine whether growth had occurred.

Additionally, one of the primary benefits of utilizing DEA-based methodology was the determination of efficient peer institutions from which inefficient institutions could learn. From a

practical application perspective, representatives from inefficient institutions could use the listing of peer institutions that were found to be technically efficient in this study. These institutional representatives could contact efficient peer institutions to discuss ways in which inefficiencies could be reduced based on the best practices exhibited by those institutions operating on the efficiency frontier.

One of the primary recommendations for future research would concern the inclusion of panel data as opposed to the cross-sectional data utilized in this study. While a single-year snapshot of data provided a point-in-time calculation of estimated efficiency, multi-year panel data would allow for the estimation of efficiency change over time and would provide a more comprehensive, robust set of results from which additional analyses could be conducted. Due to the long-term nature of institutional change in higher education, the capacity to track changes across multiple years would also provide an improvement over analyses conducted with single-year, cross-sectional data.

Future research could also include additional output variables in the analysis. One of the benefits of the DEA-based analyses is that multiple outputs can be modeled directly due to minimal assumptions placed on the data. In the context of the Arkansas performance-funding program, the mandatory progression measure is a novel approach to capturing institutional effectiveness in retaining students. The progression measure tracks a cohort of credential-seeking students who enroll in six or more credit hours during a fall semester over two academic years to see what percentage of those students earned 18 or more credit hours during that time period (ADHE, 2011). This approach differs from the typical IPEDS-based retention rate calculation that includes only first-time, full-time degree-seeking students. Future research, especially as it

pertains to Arkansas, could determine a means for collecting the data necessary to include the Arkansas progression measure as a second output within the stage-one DEA estimation model.

Specifically related to Simar and Wilson's (2007) double bootstrap truncated regression approach used in this study, other segments of higher education could be studied using this technique. While several researchers have applied the procedure to study efficiency and determinants of efficiency of post-secondary institutions internationally, few researchers have applied this technique to the context of higher education in the United States. With the emphasis in higher education policy on increasing the number of adults with post-secondary credentials, studying the efficiency of two-year colleges using Simar and Wilson's technique might provide additional insights into how to increase not only the production, but also the efficiency, of this segment of higher education in the United States.

With regard to performance-funding policy research, an area of inquiry could be the discrepancy in resource levels between inefficient institutions in states that have performance-funding programs and those that do not. This element was discovered through additional analyses following the stage-two truncated regression conducted in this study that showed the existence of performance funding had a positive impact on the larger group of institutions while having a negative impact on the medium/smaller group of institutions.

Discussion

This study used an output-oriented DEA model based on Shephard's (1970) output distance function under the assumption of variable returns to scale (VRS). Within this frame, efficient DMUs are those with a technical efficiency score of 1.0, while inefficient institutions have a technical efficiency score below 1.0. In the DEA technique, the efficient institutions create an efficiency frontier against which the inefficient institutions can be measured. One

output (number of bachelor's degrees awarded during 2011-2012) and five inputs (total number of undergraduate students, full-time equivalent academic staff, full-time equivalent administrative staff, total revenues, and total education and general expenditures) were included in the stage-one analysis. Based on the results of the analytical techniques used in this study, the Arkansas Master's institutions, in comparison to their respective larger and medium/smaller group peers, were all deemed inefficient with a technical efficiency score below 1.0. The Arkansas institutions exhibited high levels of scale efficiency with scores above 0.94 on a 0 to 1 ratio scale, suggesting that inefficiency at these Master's universities was primarily due to pure technical inefficiency within institutions in converting the inputs included in the DEA model into output.

In the larger group, UCA had the highest technical efficiency score of the larger Arkansas institutions of 0.69, indicating UCA was operating at 69% efficiency when compared to the efficient peers in the larger group. ASU had a technical efficiency score of 0.66, while ATU had the lowest of the three larger Arkansas institutions with a technical efficiency score of 0.6. In order for each of the institutions to be operating on the efficiency frontier given their existing level of output (bachelor's degrees awarded), UCA would have to reduce the five inputs included in the study by 31%, ASU by 34%, and ATU by 40%. In the medium/smaller group, HSU had the highest technical efficiency score (0.53) of the Arkansas universities, while SAU's had a technical efficiency score of 0.52 and UAM's estimated efficiency score was 0.41. In order for each of the Arkansas institutions to operate on the efficiency frontier given their existing level of output (bachelor's degrees awarded), HSU would have to reduce the inputs in the study by 47%, SAU by 48%, and UAM by 59%.

Through the second stage of the Simar and Wilson's (2007) double bootstrap truncated regression approach, the bias-corrected technical efficiency scores of inefficient institutions, as calculated in the stage-one procedure, were regressed on the following environmental variables: per capita real gross domestic product (GDP) by state during 2012; net tuition share of operating revenues in 2011-2012; percentage of the state's population (25 – 34 years old) with a bachelor's degree or higher in 2012; higher education's share as a percent of state's total expenditures in 2012; and, existence of state performance-funding program during 2011-2012. Separate analyses for the larger and medium/smaller groups were conducted. For both groups, GDP had a positive, statistically significant impact on technical efficiency when other variables were held constant, as indicated by the value of zero not falling within the 95% confidence interval. For the larger group, net tuition share was positive and significantly associated with efficiency, *ceteris paribus*, although it was not significant in the medium/smaller group. The share of total state expenditures on higher education was negatively and significantly associated with technical efficiency for the medium/smaller group, and was negative but not significant in the larger group. Neither the existence of performance funding nor educational attainment were statistically significant for either group.

While the existence of a performance-funding program in a state during 2011-2012 was not a significant determinant of estimated efficiency for either group, an interesting finding in this study was that the sign in front of the performance funding bias-corrected coefficient was opposite for the two groups. In the medium/smaller group, the sign was negative, indicating that the existence of a performance-funding program decreased the technical efficiency of institutions in this group by 0.96 percentage points. In the larger group, the sign was positive, indicating that

the existence of a performance-funding program increased the technical efficiency of institutions in this group by 0.53 percentage points.

A further review of the underlying data clarified why this discrepancy existed. The groups were similar in the proportion of inefficient institutions from states with performance-funding programs, as the larger group consisted of 30% (46 of 152) and the medium/smaller group consisted of 34% (28 of 82) of institutions in states that had a performance-funding program in place during 2011-2012. However, the institutions in the larger group from states with performance funding had an average technical efficiency score that was higher (0.74 versus 0.73) than the institutions from non-performance funding states. For the medium/smaller group, the average technical efficiency score for institutions from states with performance funding was 10 percentage points lower than the institutions from non-performance funding states (0.61 versus 0.71). In the larger group, the institutions from performance-funding states produced 8% fewer bachelor's degrees (1,678 versus 1,840), on average, than their non-performance funding counterparts. A 25% discrepancy in average output existed in the medium/smaller group, as the average degree production from institutions within performance funding states was 739, as compared to the average of 990 bachelor's degrees for institutions not in states with performance-funding programs.

A review of the inputs also provided an indication as to why there was a difference between the large and medium/smaller groups on the direction of the impact of performance-funding programs in the second-stage regression analysis. Across the five inputs included in the DEA model for the larger group, institutions from states with performance funding had an average of 16% less in resources in comparison to their counterparts not in states with performance funding. The maximum difference between institution types in the larger group was

the average number of full-time equivalent administrative staff, as the institutions in performance-funding states had an average of 23% fewer administrative staff members than institutions not located in performance funding states.

In the medium/smaller group, however, the institutions from states with a performance-funding program had, on average, 8% less in the way of resources across the five input variables included in the analysis. Much of this shift was due to the institutions from performance-funding states actually having, on average, 18% *more* full-time equivalent administrative staff than institutions located in non-performance funding states. In summary, the institutions in the larger group from states with performance-funding programs were more efficient (+1%) than institutions not located in performance-funding states, while institutions in the medium/smaller group from states with performance-funding programs were less efficient (-10%) in comparison to institutions not located in performance-funding states.

Chapter Summary

The research conducted in this study provided a measure of efficiency for four-year public Master's universities in Arkansas in comparison to a large proportion of the four-year public Master's College and Universities in the United States. The results of this study fill a void in the existing performance-funding program in Arkansas that includes a variety of performance outcome measures, but fails to address the need to achieve those outcomes in an efficient manner. Given the decreasing proportion of state funding for higher education coupled with calls for greater accountability for outcomes and resource utilization, demonstrating the efficient conversion of inputs to outputs is paramount to the successful achievement of goals and objectives.

This chapter initially presented the different components that comprised the study, followed by a brief explication and discussion of the findings of the study. The primary findings of this study were that the six public Master's institutions in Arkansas that were included in the study were found to be technically inefficient in producing bachelor's degrees, given the inputs included in the model, during the 2011-2012 academic year. Much of the demonstrated inefficiency was due to pure technical inefficiency at the institutional level, as all six institutions were operating near optimal scale size based on scale efficiency scores above 0.94. The primary findings from the stage-two truncated regression analysis were that DGP was a positive, significant determinant of technical efficiency for both groups; higher education's share of total state allocations was negative and statistically significant for the medium/smaller group of institutions; and the percentage of net tuition was positive and statistically significant for the larger group. The existence of performance funding was a not a significant determinant of technical efficiency in either group, although the variable had a different impact on each group as shown by the signs in front of the coefficients being flipped (+ for larger group and – for medium/smaller group).

The presentation of findings were followed by a discussion of seven conclusions drawn from the study, which was followed by a brief summary of the limitations existing in this study. A section of recommendations for future practice and research consisted of six recommendations pertaining to the incorporation of the findings within the existing performance-funding program in Arkansas. Recommendations for future research included expanding the use of the analytical technique to different segments of higher education in the United States, as well as a suggestion for the inclusion of additional outputs in the stage-one DEA estimation model. The use of panel

data to measure change in institutional efficiency over time was also recommended for future research efforts.

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APPENDICIES

Appendix A

Inputs and Outputs in DEA Studies of Higher Education

Citation	Inputs	Outputs
Johnes (2006)	Undergraduate quality	number of first degrees awarded
	number of FTE postgrad students	number of higher degrees awarded
	number of full-time academic staff	recurrent research grants
	capital expenditures	
	library/information expenditures	
	administrative expenditures	
Archibald & Feldman (2008)	% of students in HS top 10%	6-year graduation rate
	25th percentile ACT score	
	% full-time faculty	
	cost per undergraduate	
Flegg et al. (2004)	number of staff	research/consultancy income
	number of undergraduate students	number of UG degrees awarded
	number of postgraduate students	number of Grad degrees awarded
	aggregate departmental expenditure	
Agasisti & Dal Bianco (2006)	laboratories	regional/national revenues
	highly-qualified human resources	international revenues
	administrative personnel	order-based revenues
		yearly number of publications
		number of doctorates awarded in cooperation with external funding bodies
Johnes (2008)	full-time academic staff	UG degrees/qualifications
	administrative expenditures	Grad degrees/qualifications
	academic expenditures	research income
	FTE undergraduate enrollment	
	FTE postgraduate enrollment	

Citation	Inputs	Outputs
Worthington & Lee (2008)	FTE academic staff FTE non-academic staff non-labour input expenditure actual undergraduate student load actual postgraduate student load	undergraduate completions postgraduate completions PhD completions national competitive grants industry and other grants publications
Agasisti & Johnes (2009)	number of students financial resources/incomes number of PhD students number of academic staff	bachelor graduates masters graduates external research grants/contracts
Agasisti & Dal Bianco (2009)	total enrollments first-year students scoring high (9/10) on secondary school exam number of regular students total number of students total staff facilities/structures	number of graduates number of graduates in four or five year courses
Lee (2011)	FTE staff capital expenditures	national competitive grants industry grants other public sector grants research publications number of 'Master's' and 'Doctorate students
Wolszczak-Derlacz & Parteka (2011)	total academic staff number of students total revenues	number of graduations number of scientific publications
Sav (2012)	teaching and research faculty administrative faculty academic support expenditures on capital equipment expenditures auxiliary equipment	AY credit hour production
Parteka & Wolszczak-Derlacz (2013)	number of students total academic staff total revenues	number of publications number of graduates

Appendix B

Definition of Input, Output, and Environmental Variables Included in the Study

Variables	Definition – From IPEDS glossary unless specified
Stage One: Output	
bachelor_degrees:	Total number of awards conferred (baccalaureate or equivalent degree, as determined by the Secretary, U.S. Department of Education) that normally require at least 4 but not more than 5 years of full-time equivalent college-level work. This includes all bachelor's degrees conferred in a 5-year cooperative (work-study) program. A cooperative plan provides for alternate class attendance and employment in business, industry, or government; thus, it allows students to combine actual work experience with their college studies. Also includes bachelor's degrees in which the normal 4 years of work are completed in 3 years.
Stage One: Inputs	
undergraduates:	The total number of undergraduate students.
academic_staff:	Persons identified by the institution as such and typically those whose initial assignments are made for the purpose of conducting instruction, research or public service as a principal activity (or activities). They may hold academic rank titles of professor, associate professor, assistant professor, instructor, lecturer or the equivalent of any of those academic ranks. Faculty may also include the chancellor/president, provost, vice provosts, deans, directors or the equivalent, as well as associate deans, assistant deans and executive officers of academic departments (chairpersons, heads or the equivalent) if their principal activity is instruction combined with research and/or public service. The designation as "faculty" is separate from the activities to which they may be currently assigned. For example, a newly appointed president of an institution may also be appointed as a faculty member. Graduate, instruction, and research assistants are not included in this category.
admin_staff:	A primary function or occupational activity category used to classify persons whose assignments require management of the institution, or a customarily recognized department or subdivision thereof. Assignments require the performance of work directly related to management policies or general business operations of the institution, department or subdivision. Assignments in this category customarily and regularly require the incumbent to exercise discretion and independent judgment.

Variables	Definition – From IPEDS glossary unless specified
revenues:	The inflow of resources or other enhancement of net assets (or fund balance) of an institution or settlements of its liabilities (or a combination of both) from delivering or producing goods, rendering services, or other activities that constitute the institution's ongoing major or central operations. Includes revenues from fees and charges, appropriations, auxiliary enterprises, and contributions and other nonexchange transactions. Revenues are reported net of discounts and allowances (that is, the revenue reported is reduced by the amount of discounts and allowances) for FASB institutions and for GASB institutions that have implemented GASB Statement No. 34.
expenditures:	Total education and general expenditures includes all core operating expenditures, including sponsored research, but excluding auxiliary enterprises. This variable was originally reported in IPEDS, but for recent years it is calculated by summing expenditures on instruction, research, public service, academic support, student services, institutional support, operations and maintenance, and scholarships and fellowships.
Stage Two: Environmental	
GDP:	A dollar amount representing the state's per capita real GDP during 2012.[a]
net_tuition:	The net tuition share of operating revenues (net tuition; federal, state, and local appropriations grants, and contracts; and private gifts, grants, and contracts).
attainment:	Percentage of the state's population (25-34 years old) with a bachelor's degree or higher in 2012.[b]
share:	Higher education's share as a percentage of state's total expenditures in 2012.[c]
performance_funding:	A dichotomous variable indicating the existence of an active state performance-funding program during 2012.[d]

[a]Source: Bureau of Economic Analysis (http://www.bea.gov/regional/index.htm)
[b]Source: NCHEMS Information Center (http://www.higheredinfo.org/)
[c]Source: NASBO (2013)
[d]Source: Gorbunov (2013)

Appendix C

Descriptive Statistics of Variables by Group, 2011-2012 Academic Year

	Mean	StdDev	Median	Minimum	Maximum
Larger Group (*n*=167)					
bachelor_degrees	1,916.66	1,256.57	1,592.00	198.00	7,044.00
undergraduates	9,917.61	5,859.88	8,696.00	1,450.00	31,747.00
academic_staff_FTE	511.43	256.25	462.00	68.00	1,282.00
admin_staff_FTE	76.99	51.19	64.00	5.00	387.00
revenues ($)	104,726,068.63	60,463,602.42	88,943,766.00	8,357,805.00	339,915,957.00
expenditures ($)	157,230,751.43	87,089,520.82	132,494,894.00	20,781,183.00	432,697,969.00
GDP ($)	48,871.33	8,017.78	48,109.00	31,985.00	72,281.00
share (%)	11.42	6.23	9.70	2.50	25.70
attainment (%)	32.94	6.48	31.97	21.62	48.98
net_tuition_share (%)	58.95	13.14	59.42	32.51	109.49
Medium/Smaller Group (*n*=93)					
bachelor_degrees	928.20	561.54	785.00	106.00	2,691.00
undergraduates	4,962.39	2,749.02	4,729.00	1,102.00	18,461.00
academic_staff_FTE	260.42	120.08	239.00	70.00	639.00
admin_staff_FTE	46.28	28.18	41.00	7.00	156.00
revenues ($)	51,899,185.28	34,555,409.59	42,440,294.00	8,754,304.00	202,096,090.00
expenditures ($)	76,260,774.05	37,509,270.92	68,897,925.00	21,833,013.00	184,758,406.00
GDP ($)	48,027.92	8,714.11	47,634.00	31,985.00	72,281.00
share (%)	12.16	5.66	10.90	1.80	23.10
attainment (%)	31.78	6.70	30.73	21.62	48.98
net_tuition_share (%)	52.35	15.55	50.84	15.92	99.24

Appendix D

Returns to Scale, Master's Medium/Smaller Institutions, 2011-2012

Institution	VRS	CRS	SE	Returns to Scale[a]
University of Montevallo	0.537	0.492	0.916	drs
Henderson State University	0.531	0.524	0.987	drs
Southern Arkansas University Main Campus	0.515	0.492	0.956	drs
California State University-San Marcos	0.901	0.738	0.818	drs
Humboldt State University	0.753	0.685	0.909	drs
Adams State University	0.442	0.432	0.978	drs
Western Connecticut State University	0.617	0.571	0.925	drs
Delaware State University	0.474	0.414	0.873	drs
University of South Florida-Sarasota-Manatee	1.000	1.000	1.000	crs
University of South Florida-St Petersburg	0.748	0.730	0.977	irs
Albany State University	0.546	0.504	0.923	drs
Southern Polytechnic State University	0.546	0.510	0.935	drs
Indiana University-Northwest	0.339	0.338	0.996	drs
Indiana University-South Bend	0.442	0.431	0.975	drs
Washburn University	0.558	0.483	0.865	drs
Grambling State University	0.558	0.495	0.887	drs
Louisiana State University-Shreveport	0.585	0.576	0.985	drs
Nicholls State University	0.572	0.528	0.922	drs
Southern University at New Orleans	0.395	0.379	0.959	drs
Westfield State University	0.948	0.805	0.849	drs
Worcester State University	0.700	0.611	0.874	drs
Northern Michigan University	0.605	0.549	0.907	drs
Metropolitan State University	1.000	1.000	1.000	crs
Minnesota State University-Moorhead	0.893	0.886	0.991	irs
Southwest Minnesota State University	1.000	0.756	0.756	irs
University of Minnesota-Duluth	0.850	0.673	0.792	drs
Winona State University	0.983	0.902	0.917	drs
Truman State University	0.864	0.860	0.995	drs
Alcorn State University	0.403	0.369	0.917	drs
Mississippi Valley State University	0.549	0.523	0.954	drs
Montana State University-Billings	0.413	0.385	0.933	drs
Fayetteville State University	0.741	0.710	0.958	drs
University of North Carolina at Pembroke	0.644	0.569	0.883	drs
Winston-Salem State University	0.863	0.773	0.896	drs
Minot State University	0.760	0.749	0.986	drs
Ramapo College of New Jersey	0.920	0.884	0.961	drs
The Richard Stockton College of New Jersey	1.000	0.853	0.853	drs
New Mexico Institute of Mining and Technology	0.644	0.476	0.739	irs
Western New Mexico University	0.284	0.268	0.945	drs
SUNY at Fredonia	0.886	0.835	0.942	drs
SUNY Empire State College	0.963	0.693	0.719	drs

Institution	VRS	CRS	SE	Returns to Scale[a]
SUNY Institute of Technology at Utica-Rome	0.782	0.775	0.991	drs
Southeastern Oklahoma State University	0.611	0.589	0.964	drs
Southwestern Oklahoma State University	0.492	0.471	0.957	drs
Western Oregon University	0.778	0.759	0.976	irs
Mansfield University of Pennsylvania	0.711	0.695	0.977	irs
College of Charleston	0.895	0.758	0.847	drs
The University of Tennessee-Martin	0.629	0.565	0.898	drs
Angelo State University	0.582	0.513	0.882	drs
Midwestern State University	0.771	0.735	0.954	drs
The University of Texas at Brownsville	0.550	0.357	0.650	drs
The University of Texas of the Permian Basin	0.725	0.657	0.906	drs
Weber State University	1.000	0.722	0.722	drs
Longwood University	0.768	0.746	0.971	drs
Central Washington University	1.000	0.890	0.890	drs
University of Wisconsin-Eau Claire	0.922	0.768	0.833	drs
University of Wisconsin-River Falls	0.823	0.776	0.942	drs
University of Wisconsin-Stevens Point	0.861	0.788	0.915	drs
University of Alaska Southeast	1.000	0.219	0.219	irs
University of Arkansas at Monticello	0.407	0.382	0.940	drs
California State University-Channel Islands	0.938	0.891	0.951	drs
California State University-Monterey Bay	0.674	0.628	0.933	drs
Colorado State University-Pueblo	0.792	0.760	0.960	drs
Eastern Connecticut State University	0.847	0.828	0.978	drs
Georgia Southwestern State University	0.652	0.640	0.981	drs
Coppin State University	0.550	0.518	0.941	irs
University of Maryland Eastern Shore	0.586	0.511	0.871	drs
Bemidji State University	0.815	0.765	0.938	irs
Lincoln University	0.383	0.356	0.930	drs
Mississippi University for Women	0.821	0.808	0.984	drs
Keene State College	0.996	0.912	0.916	drs
Eastern New Mexico University-Main Campus	0.630	0.601	0.953	irs
Fashion Institute of Technology	0.674	0.622	0.922	drs
SUNY College at Geneseo	0.884	0.813	0.920	drs
SUNY Oneonta	0.892	0.833	0.934	drs
Cameron University	0.376	0.369	0.982	drs
Langston University	0.449	0.422	0.939	drs
Northwestern Oklahoma State University	1.000	0.605	0.605	irs
Eastern Oregon University	1.000	1.000	1.000	crs
Cheyney University of Pennsylvania	1.000	0.479	0.479	irs
Lock Haven University	0.703	0.698	0.993	irs
Coastal Carolina University	0.758	0.694	0.915	drs
Francis Marion University	0.596	0.566	0.950	drs
Black Hills State University	0.596	0.573	0.961	drs
Dakota State University	0.455	0.450	0.988	drs

Institution	VRS	CRS	SE	Returns to Scale[a]
Christopher Newport University	0.826	0.777	0.940	drs
Virginia State University	0.588	0.495	0.842	drs
Johnson State College	0.926	0.671	0.725	irs
The Evergreen State College	1.000	0.942	0.942	drs
University of Wisconsin-Green Bay	0.902	0.896	0.993	irs
University of Wisconsin-Superior	0.690	0.647	0.938	drs
Fairmont State University	0.559	0.511	0.915	drs
Shepherd University	0.631	0.619	0.982	drs

[a]irs=increasing returns to scale; drs=decreasing returns to scale; crs=constant returns to scale

Appendix E

Returns to Scale, Master's Larger Institutions, 2011-2012

Institution	VRS	CRS	SE	Returns to Scale[a]
University of Alaska Anchorage	0.326	0.296	0.907	drs
Alabama A & M University	0.460	0.448	0.973	irs
Alabama State University	0.398	0.396	0.994	irs
Auburn University at Montgomery	0.471	0.465	0.986	irs
Jacksonville State University	0.654	0.653	0.998	irs
Troy University	0.719	0.640	0.889	drs
University of North Alabama	0.714	0.708	0.992	irs
University of West Alabama	0.369	0.347	0.941	irs
Arkansas State University-Main Campus	0.664	0.664	1.000	drs
Arkansas Tech University	0.600	0.599	0.997	irs
University of Central Arkansas	0.692	0.692	0.999	irs
California Polytechnic State University-San Luis Obispo	0.850	0.821	0.966	drs
California State Polytechnic University-Pomona	1.000	0.972	0.972	drs
California State University-Bakersfield	1.000	1.000	1.000	crs
California State University-Chico	1.000	1.000	1.000	crs
California State University-Dominguez Hills	0.881	0.872	0.989	drs
California State University-East Bay	1.000	1.000	1.000	crs
California State University-Fresno	1.000	1.000	1.000	drs
California State University-Fullerton	1.000	0.977	0.977	drs
California State University-Long Beach	1.000	0.958	0.958	drs
California State University-Los Angeles	0.943	0.931	0.988	drs
California State University-Northridge	1.000	0.955	0.955	drs
California State University-Sacramento	1.000	1.000	1.000	crs
California State University-San Bernardino	0.888	0.871	0.982	drs
California State University-Stanislaus	0.826	0.818	0.990	irs
San Francisco State University	0.975	0.938	0.962	drs
San Jose State University	0.877	0.848	0.967	drs
Sonoma State University	0.900	0.894	0.994	irs
University of Colorado Colorado Springs	0.746	0.744	0.998	irs
Central Connecticut State University	0.827	0.775	0.937	drs
Southern Connecticut State University	0.816	0.768	0.942	drs
Florida Gulf Coast University	0.637	0.634	0.995	drs
University of North Florida	0.975	0.945	0.968	drs

Institution	VRS	CRS	SE	Returns to Scale[a]
Armstrong Atlantic State University	0.544	0.540	0.993	irs
Augusta State University	0.483	0.479	0.992	irs
Columbus State University	0.470	0.469	0.996	irs
Georgia College and State University	0.820	0.816	0.996	drs
Kennesaw State University	0.752	0.648	0.862	drs
University of North Georgia	0.707	0.698	0.988	irs
University of West Georgia	0.643	0.642	0.998	drs
Valdosta State University	0.657	0.654	0.996	drs
University of Northern Iowa	0.941	0.886	0.942	drs
Boise State University	0.659	0.632	0.959	drs
Chicago State University	0.498	0.497	0.997	drs
Eastern Illinois University	0.862	0.801	0.929	drs
Governors State University	1.000	1.000	1.000	crs
Northeastern Illinois University	0.718	0.718	1.000	crs
Southern Illinois University-Edwardsville	0.752	0.693	0.922	drs
University of Illinois at Springfield	0.734	0.726	0.989	irs
Western Illinois University	0.862	0.795	0.922	drs
Indiana University-Purdue University-Fort Wayne	0.440	0.440	1.000	drs
Indiana University-Southeast	0.611	0.611	0.999	drs
Purdue University-Calumet Campus	0.524	0.523	0.999	irs
University of Southern Indiana	0.645	0.645	1.000	drs
Emporia State University	0.707	0.704	0.997	irs
Fort Hays State University	1.000	1.000	1.000	crs
Pittsburg State University	0.745	0.741	0.995	irs
Eastern Kentucky University	0.655	0.598	0.912	drs
Morehead State University	0.589	0.589	1.000	irs
Murray State University	0.730	0.718	0.983	drs
Northern Kentucky University	0.631	0.604	0.957	drs
Western Kentucky University	0.701	0.642	0.916	drs
McNeese State University	0.638	0.635	0.995	irs
Northwestern State University of Louisiana	0.593	0.590	0.996	irs
Southeastern Louisiana University	0.652	0.648	0.993	drs
Southern University and A & M College	0.481	0.479	0.995	drs
University of Louisiana at Monroe	0.653	0.652	0.998	irs
Bridgewater State University	0.819	0.817	0.998	drs
Fitchburg State University	0.815	0.802	0.984	irs
Framingham State University	0.737	0.723	0.982	irs
Salem State University	0.795	0.794	0.999	irs

Institution	VRS	CRS	SE	Returns to Scale[a]
University of Massachusetts-Dartmouth	0.624	0.611	0.980	drs
Frostburg State University	0.721	0.712	0.988	irs
Salisbury University	0.966	0.964	0.997	irs
Towson University	0.990	0.933	0.942	drs
University of Baltimore	0.640	0.634	0.991	irs
University of Maryland-University College	0.685	0.585	0.855	drs
University of Southern Maine	0.831	0.816	0.982	drs
Eastern Michigan University	0.653	0.591	0.904	drs
Ferris State University	0.694	0.680	0.979	drs
Grand Valley State University	0.915	0.827	0.904	drs
Saginaw Valley State University	0.572	0.572	1.000	drs
University of Michigan-Dearborn	0.646	0.645	0.999	irs
University of Michigan-Flint	0.641	0.639	0.997	irs
Minnesota State University-Mankato	0.850	0.829	0.975	drs
Saint Cloud State University	0.868	0.846	0.974	drs
Missouri State University-Springfield	0.829	0.811	0.978	drs
Northwest Missouri State University	0.777	0.764	0.984	irs
Southeast Missouri State University	0.682	0.681	0.998	irs
University of Central Missouri	0.802	0.799	0.996	drs
Delta State University	0.630	0.619	0.983	irs
Appalachian State University	0.937	0.922	0.985	drs
North Carolina Central University	0.552	0.546	0.990	drs
University of North Carolina Wilmington	0.936	0.921	0.984	drs
Western Carolina University	0.874	0.874	1.000	drs
Peru State College	1.000	0.990	0.990	irs
University of Nebraska at Kearney	0.652	0.646	0.990	irs
Wayne State College	0.778	0.745	0.958	irs
Plymouth State University	0.790	0.779	0.986	irs
Kean University	0.750	0.729	0.972	drs
Montclair State University	0.855	0.782	0.915	drs
New Jersey City University	0.649	0.649	1.000	irs
Rowan University	0.800	0.758	0.948	drs
The College of New Jersey	0.888	0.878	0.989	drs
William Paterson University of New Jersey	0.763	0.750	0.984	drs
New Mexico Highlands University	0.619	0.592	0.956	irs
Buffalo State SUNY	0.732	0.719	0.982	drs
College of Staten Island CUNY	0.515	0.501	0.973	drs
CUNY Bernard M Baruch College	0.763	0.741	0.972	drs

Institution	VRS	CRS	SE	Returns to Scale[a]
CUNY Brooklyn College	0.877	0.862	0.983	drs
CUNY City College	0.616	0.568	0.921	drs
CUNY Hunter College	0.772	0.683	0.885	drs
CUNY John Jay College of Criminal Justice	0.695	0.691	0.994	drs
CUNY Lehman College	0.689	0.684	0.993	drs
CUNY Queens College	0.879	0.823	0.936	drs
State University of New York at New Paltz	1.000	1.000	1.000	crs
SUNY College at Brockport	0.920	0.919	1.000	irs
SUNY College at Cortland	0.835	0.834	0.998	irs
SUNY College at Oswego	0.870	0.868	0.997	irs
SUNY College at Plattsburgh	0.883	0.880	0.996	irs
SUNY College at Potsdam	0.754	0.746	0.990	irs
Youngstown State University	0.455	0.451	0.990	drs
East Central University	0.677	0.668	0.986	irs
Northeastern State University	0.908	0.902	0.993	irs
University of Central Oklahoma	0.687	0.657	0.957	drs
Southern Oregon University	0.660	0.642	0.973	irs
Bloomsburg University of Pennsylvania	0.774	0.766	0.990	drs
California University of Pennsylvania	0.772	0.766	0.992	irs
Clarion University of Pennsylvania	0.675	0.660	0.978	irs
East Stroudsburg University of Pennsylvania	0.843	0.826	0.980	irs
Edinboro University of Pennsylvania	0.570	0.566	0.995	irs
Kutztown University of Pennsylvania	0.811	0.811	1.000	irs
Millersville University of Pennsylvania	0.822	0.815	0.991	irs
Shippensburg University of Pennsylvania	0.792	0.788	0.995	irs
Slippery Rock University of Pennsylvania	0.965	0.959	0.994	irs
West Chester University of Pennsylvania	0.882	0.879	0.997	drs
Rhode Island College	0.685	0.685	1.000	crs
Citadel Military College of South Carolina	0.813	0.751	0.924	irs
Winthrop University	0.766	0.754	0.984	irs
Austin Peay State University	0.557	0.556	0.998	irs
Tennessee Technological University	0.757	0.738	0.975	drs
The University of Tennessee-Chattanooga	0.599	0.598	0.998	irs
Prairie View A & M University	0.546	0.545	0.998	irs
Stephen F Austin State University	0.704	0.703	0.999	irs
Sul Ross State University	0.598	0.571	0.955	irs

Institution	VRS	CRS	SE	Returns to Scale[a]
Tarleton State University	0.849	0.846	0.996	drs
Texas A & M International University	0.547	0.537	0.983	irs
Texas A & M University-Texarkana	1.000	1.000	1.000	crs
Texas State University	0.853	0.736	0.863	drs
The University of Texas at Tyler	0.822	0.819	0.996	irs
The University of Texas-Pan American	0.651	0.634	0.973	drs
University of Houston-Clear Lake	0.964	0.963	0.998	irs
University of Houston-Victoria	1.000	1.000	1.000	crs
West Texas A & M University	0.791	0.784	0.991	irs
Southern Utah University	0.608	0.602	0.990	irs
James Madison University	0.986	0.917	0.930	drs
Norfolk State University	0.500	0.495	0.990	irs
Radford University	0.940	0.932	0.992	drs
University of Mary Washington	0.984	0.951	0.967	irs
Eastern Washington University	0.781	0.776	0.993	drs
Western Washington University	0.967	0.956	0.989	drs
University of Wisconsin-La Crosse	0.824	0.823	0.999	drs
University of Wisconsin-Oshkosh	0.787	0.783	0.994	drs
University of Wisconsin-Platteville	0.663	0.661	0.997	irs
University of Wisconsin-Stout	0.746	0.746	1.000	irs
University of Wisconsin-Whitewater	0.816	0.813	0.997	drs
Marshall University	0.604	0.539	0.892	drs

[a]irs=increasing returns to scale; drs=decreasing returns to scale; crs=constant returns to scale

Appendix F

Input Slacks for Inefficient Institutions, Medium/Smaller Group Institutions

	Input Variables (%)				
Institution	x1	x2	x3	x4	x5
University of Montevallo	0.00	23.29	0.00	33.96	11.21
Henderson State University	0.00	27.20	0.00	16.84	14.26
Southern Arkansas University Main Campus	0.00	32.63	2.45	2.99	0.00
California State University-San Marcos	14.71	11.69	14.19	0.00	42.99
Humboldt State University	0.00	10.40	32.23	0.00	41.62
Adams State University	0.00	26.32	0.00	61.33	7.49
Western Connecticut State University	0.00	33.69	0.00	32.15	37.20
Delaware State University	0.00	34.24	0.00	24.24	32.71
University of South Florida-Sarasota-Manatee	0.00	0.00	0.00	0.00	0.00
University of South Florida-St Petersburg	7.46	0.00	44.55	44.52	22.89
Albany State University	0.00	7.46	0.00	16.01	6.91
Southern Polytechnic State University	0.00	19.02	37.76	30.37	0.00
Indiana University-Northwest	0.00	21.59	0.00	12.28	3.25
Indiana University-South Bend	0.00	32.97	0.00	14.85	2.45
Washburn University	0.00	37.18	40.84	0.00	22.50
Grambling State University	0.00	20.83	0.00	23.74	8.29
Louisiana State University-Shreveport	0.00	1.01	0.00	13.65	6.10
Nicholls State University	0.00	8.44	7.88	1.53	0.00
Southern University at New Orleans	0.00	3.89	13.65	0.00	5.54
Westfield State University	0.00	27.59	27.05	24.37	0.00
Worcester State University	0.00	24.36	26.38	15.22	0.00
Northern Michigan University	0.00	0.00	0.00	3.59	4.63
Metropolitan State University	0.00	0.00	0.00	0.00	0.00
Minnesota State University-Moorhead	0.00	26.12	0.00	44.91	14.03
Southwest Minnesota State University	0.00	0.00	0.00	0.00	0.00
University of Minnesota-Duluth	0.00	12.89	46.12	6.69	11.62
Winona State University	0.00	20.93	0.00	55.47	19.04
Truman State University	0.00	34.97	0.00	53.23	26.43
Alcorn State University	0.00	19.95	0.00	36.63	36.64

Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
Mississippi Valley State University	0.00	28.57	24.42	35.89	30.95
Montana State University-Billings	0.00	13.96	0.00	16.58	1.10
Fayetteville State University	0.00	33.55	48.09	0.00	45.24
University of North Carolina at Pembroke	0.00	37.05	29.00	0.00	24.69
Winston-Salem State University	0.00	42.78	29.99	0.00	41.41
Minot State University	0.00	43.42	0.00	44.93	28.84
Ramapo College of New Jersey	0.00	26.65	0.00	67.72	35.35
The Richard Stockton College of New Jersey	0.00	0.00	0.00	0.00	0.00
New Mexico Institute of Mining and Technology	0.00	46.12	81.06	82.47	68.63
Western New Mexico University	0.00	43.91	33.71	0.00	9.13
SUNY at Fredonia	0.00	35.06	0.00	46.36	33.07
SUNY Empire State College	24.72	43.35	39.17	0.00	41.39
SUNY Institute of Technology at Utica-Rome	0.00	23.03	0.00	44.53	45.29
Southeastern Oklahoma State University	0.00	11.77	0.00	16.70	6.93
Southwestern Oklahoma State University	0.00	24.31	0.00	18.69	18.71
Western Oregon University	0.00	34.12	0.00	56.45	19.79
Mansfield University of Pennsylvania	0.00	13.37	0.00	59.53	33.46
College of Charleston	0.00	26.52	24.06	29.49	15.17
The University of Tennessee-Martin	0.00	20.32	35.67	0.00	19.78
Angelo State University	0.00	12.97	18.88	19.17	0.00
Midwestern State University	0.00	15.75	0.00	25.01	23.11
The University of Texas at Brownsville	29.90	29.26	69.04	0.00	38.58
The University of Texas of the Permian Basin	0.00	11.10	19.91	0.00	19.16
Weber State University	0.00	0.00	0.00	0.00	0.00
Longwood University	0.00	30.66	0.00	69.82	32.31
Central Washington University	0.00	0.00	0.00	0.00	0.00
University of Wisconsin-Eau Claire	0.00	9.19	0.00	2.79	4.15
University of Wisconsin-River Falls	0.00	11.04	0.00	38.19	10.67
University of Wisconsin-Stevens Point	0.00	4.35	0.00	5.48	7.34
University of Alaska Southeast	0.00	0.00	0.00	0.00	0.00
University of Arkansas at Monticello	0.00	21.76	22.72	0.00	11.81

Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
California State University-Channel Islands	0.00	5.96	0.00	27.30	53.02
California State University-Monterey Bay	0.00	8.15	21.81	0.00	50.99
Colorado State University-Pueblo	10.57	36.88	0.00	54.56	23.04
Eastern Connecticut State University	0.00	29.08	0.00	57.35	46.11
Georgia Southwestern State University	0.00	1.63	3.55	35.28	0.00
Coppin State University	0.00	26.33	0.00	27.63	39.99
University of Maryland Eastern Shore	0.00	35.79	0.00	29.31	20.92
Bemidji State University	0.00	0.00	0.00	32.15	8.47
Lincoln University	0.00	39.75	27.64	0.00	32.81
Mississippi University for Women	0.00	32.43	0.00	44.44	26.97
Keene State College	0.00	30.07	0.00	61.83	15.74
Eastern New Mexico University-Main Campus	0.00	2.59	0.00	32.84	23.00
Fashion Institute of Technology	0.00	31.37	22.38	0.00	50.71
SUNY College at Geneseo	0.00	19.75	0.00	39.91	25.43
SUNY Oneonta	0.00	28.07	0.00	46.96	35.60
Cameron University	0.00	2.36	38.08	0.00	6.32
Langston University	0.00	37.45	37.99	8.72	33.13
Northwestern Oklahoma State University	0.00	0.00	0.00	0.00	0.00
Eastern Oregon University	0.00	0.00	0.00	0.00	0.00
Cheyney University of Pennsylvania	0.00	0.00	0.00	0.00	0.00
Lock Haven University	0.00	13.03	0.00	62.24	30.44
Coastal Carolina University	0.00	26.29	0.00	68.96	41.10
Francis Marion University	0.00	31.15	0.00	26.57	25.77
Black Hills State University	0.00	14.57	56.55	51.83	0.00
Dakota State University	0.00	18.82	38.56	52.27	19.43
Christopher Newport University	0.00	32.41	0.00	61.76	20.71
Virginia State University	0.00	30.86	16.62	0.00	2.44
Johnson State College	0.00	4.77	0.00	40.86	0.00
The Evergreen State College	0.00	0.00	0.00	0.00	0.00
University of Wisconsin-Green Bay	6.48	0.00	37.61	52.73	22.53
University of Wisconsin-Superior	0.00	20.15	0.00	28.50	18.41
Fairmont State University	0.00	19.22	0.00	22.01	6.10
Shepherd University	0.00	26.39	65.65	52.27	0.00

Input Variables: x1=undergraduates; x2=academic_staff_FTE; x3=admin_staff_FTE; x4=revenues; x5=expenditures

Appendix G

Input Slacks for Inefficient Institutions, Larger Group Institutions

Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
University of Alaska Anchorage	0.00	37.82	0.00	30.04	27.02
Alabama A & M University	0.00	5.21	0.00	37.99	28.80
Alabama State University	0.00	0.00	0.00	23.12	27.98
Auburn University at Montgomery	0.00	8.41	52.65	20.19	0.00
Jacksonville State University	0.00	10.63	54.15	2.94	0.00
Troy University	3.95	17.97	87.12	25.84	0.00
University of North Alabama	0.00	4.25	32.80	4.82	0.00
University of West Alabama	0.00	0.00	49.56	60.90	21.67
Arkansas State University-Main Campus	0.00	13.86	15.17	1.21	0.00
Arkansas Tech University	0.00	23.60	50.03	8.57	0.00
University of Central Arkansas	0.00	29.66	0.00	1.91	0.00
California Polytechnic State University-San Luis Obispo	0.00	13.68	8.23	35.09	19.33
California State Polytechnic University-Pomona	0.00	0.00	0.00	0.00	0.00
California State University-Bakersfield	0.00	0.00	0.00	0.00	0.00
California State University-Chico	0.00	0.00	0.00	0.00	0.00
California State University-Dominguez Hills	0.00	0.00	28.46	0.00	11.62
California State University-East Bay	0.00	0.00	0.00	0.00	0.00
California State University-Fresno	0.00	0.00	0.00	0.00	0.00
California State University-Fullerton	0.00	0.00	0.00	0.00	0.00
California State University-Long Beach	0.00	0.00	0.00	0.00	0.00
California State University-Los Angeles	9.82	25.02	0.00	0.00	21.60
California State University-Northridge	0.00	0.00	0.00	0.00	0.00
California State University-Sacramento	0.00	0.00	0.00	0.00	0.00
California State University-San Bernardino	0.00	0.00	21.86	10.15	25.33
California State University-Stanislaus	0.00	12.09	0.00	0.00	22.22
San Francisco State University	0.00	4.98	9.05	33.50	17.48
San Jose State University	0.00	7.95	0.00	20.80	8.62
Sonoma State University	0.00	0.00	25.74	16.93	0.00
University of Colorado Colorado Springs	0.00	31.22	67.77	41.81	0.00
Central Connecticut State University	0.00	31.92	0.00	37.11	23.35
Southern Connecticut State University	0.00	40.72	0.00	47.06	25.24
Florida Gulf Coast University	0.00	4.79	70.41	10.85	0.00
University of North Florida	0.00	17.56	83.91	8.67	0.00

Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
Armstrong Atlantic State University	0.00	21.03	54.50	17.71	0.00
Augusta State University	0.00	26.54	46.78	0.00	0.00
Columbus State University	0.00	9.44	0.09	0.00	0.00
Georgia College and State University	0.00	5.50	0.00	24.70	6.94
Kennesaw State University	7.30	20.51	63.80	19.70	0.00
University of North Georgia	0.00	31.07	63.71	32.29	0.00
University of West Georgia	0.00	23.66	38.98	19.74	0.00
Valdosta State University	0.00	25.64	48.70	26.82	0.00
University of Northern Iowa	0.00	20.92	40.09	42.06	14.87
Boise State University	0.00	13.20	56.28	40.44	0.00
Chicago State University	0.00	5.23	26.63	0.00	16.64
Eastern Illinois University	0.00	24.62	36.67	37.71	19.84
Governors State University	0.00	0.00	0.00	0.00	0.00
Northeastern Illinois University	0.00	9.75	27.48	0.00	0.00
Southern Illinois University-Edwardsville	0.00	25.75	42.24	49.85	35.87
University of Illinois at Springfield	0.00	0.00	43.70	17.20	1.95
Western Illinois University	0.00	25.53	61.56	41.42	23.91
Indiana University-Purdue University-Fort Wayne	0.00	13.33	51.91	1.65	0.00
Indiana University-Southeast	10.22	37.11	14.99	0.00	0.00
Purdue University-Calumet Campus	0.00	11.25	33.49	0.00	0.00
University of Southern Indiana	0.00	21.33	57.88	0.07	0.00
Emporia State University	0.00	9.78	45.05	0.00	0.00
Fort Hays State University	0.00	0.00	0.00	0.00	0.00
Pittsburg State University	0.00	19.20	50.96	0.00	0.00
Eastern Kentucky University	0.00	29.27	73.42	39.42	23.72
Morehead State University	0.00	1.25	4.68	0.00	0.00
Murray State University	0.00	9.03	23.07	17.25	4.13
Northern Kentucky University	0.00	18.70	52.52	31.36	10.27
Western Kentucky University	0.00	25.40	44.21	31.06	17.37
McNeese State University	0.00	25.68	37.91	0.00	0.00
Northwestern State University of Louisiana	0.00	13.95	3.35	0.00	0.00
Southeastern Louisiana University	0.00	21.39	55.06	1.70	0.00
Southern University and A & M College	0.00	8.37	18.95	0.00	3.30
University of Louisiana at Monroe	0.00	2.25	2.60	1.06	0.00
Bridgewater State University	0.00	18.87	70.22	23.29	0.00
Fitchburg State University	0.00	18.47	50.93	8.58	0.00
Framingham State University	0.00	4.02	55.72	20.43	0.00
Salem State University	0.00	18.11	61.13	0.00	0.00
University of Massachusetts-Dartmouth	0.00	6.63	13.01	45.00	27.63

Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
Frostburg State University	0.00	14.07	39.03	15.20	0.00
Salisbury University	0.00	35.25	29.76	37.91	0.00
Towson University	0.00	36.40	61.50	49.36	5.24
University of Baltimore	0.00	0.00	35.82	32.80	3.58
University of Maryland-University College	8.99	1.53	58.64	46.92	0.00
University of Southern Maine	0.00	35.08	0.00	63.71	39.54
Eastern Michigan University	0.00	22.17	54.82	42.97	24.22
Ferris State University	0.00	11.16	63.60	38.47	3.69
Grand Valley State University	0.00	31.43	60.89	50.33	8.47
Saginaw Valley State University	0.00	21.69	62.07	24.99	0.00
University of Michigan-Dearborn	0.00	1.73	46.81	5.10	0.00
University of Michigan-Flint	0.00	7.58	59.00	9.83	0.00
Minnesota State University-Mankato	0.00	15.54	0.00	25.65	0.00
Saint Cloud State University	0.00	19.95	0.00	19.86	0.00
Missouri State University-Springfield	0.00	21.81	17.99	39.14	0.00
Northwest Missouri State University	0.00	9.32	0.00	26.15	0.00
Southeast Missouri State University	0.00	0.00	19.39	34.98	0.00
University of Central Missouri	0.00	18.92	51.55	19.02	0.00
Delta State University	0.00	12.50	26.55	8.08	0.00
Appalachian State University	0.00	34.81	5.21	38.13	4.81
North Carolina Central University	0.00	20.92	23.48	0.00	20.04
University of North Carolina Wilmington	0.00	23.13	11.37	35.10	2.40
Western Carolina University	0.00	17.87	14.74	0.75	0.00
Peru State College	0.00	0.00	0.00	0.00	0.00
University of Nebraska at Kearney	0.00	28.85	19.37	14.10	0.00
Wayne State College	0.00	23.60	55.12	13.09	0.00
Plymouth State University	0.00	14.91	31.58	52.49	0.00
Kean University	0.00	18.98	53.14	30.63	5.43
Montclair State University	0.00	33.47	36.78	55.01	22.09
New Jersey City University	0.00	5.72	0.00	0.00	3.65
Rowan University	0.00	17.44	48.05	41.25	29.48
The College of New Jersey	0.00	30.20	0.00	58.80	31.91
William Paterson University of New Jersey	0.00	28.95	0.00	39.34	15.76
New Mexico Highlands University	0.00	0.00	32.40	18.41	9.54
Buffalo State SUNY	0.00	8.23	34.33	5.14	18.72
College of Staten Island CUNY	0.00	11.26	47.28	0.00	0.00
CUNY Bernard M Baruch College	0.00	9.92	56.85	26.84	16.95
CUNY Brooklyn College	0.00	30.77	51.38	3.44	26.80
CUNY City College	0.00	37.43	58.50	29.50	44.36

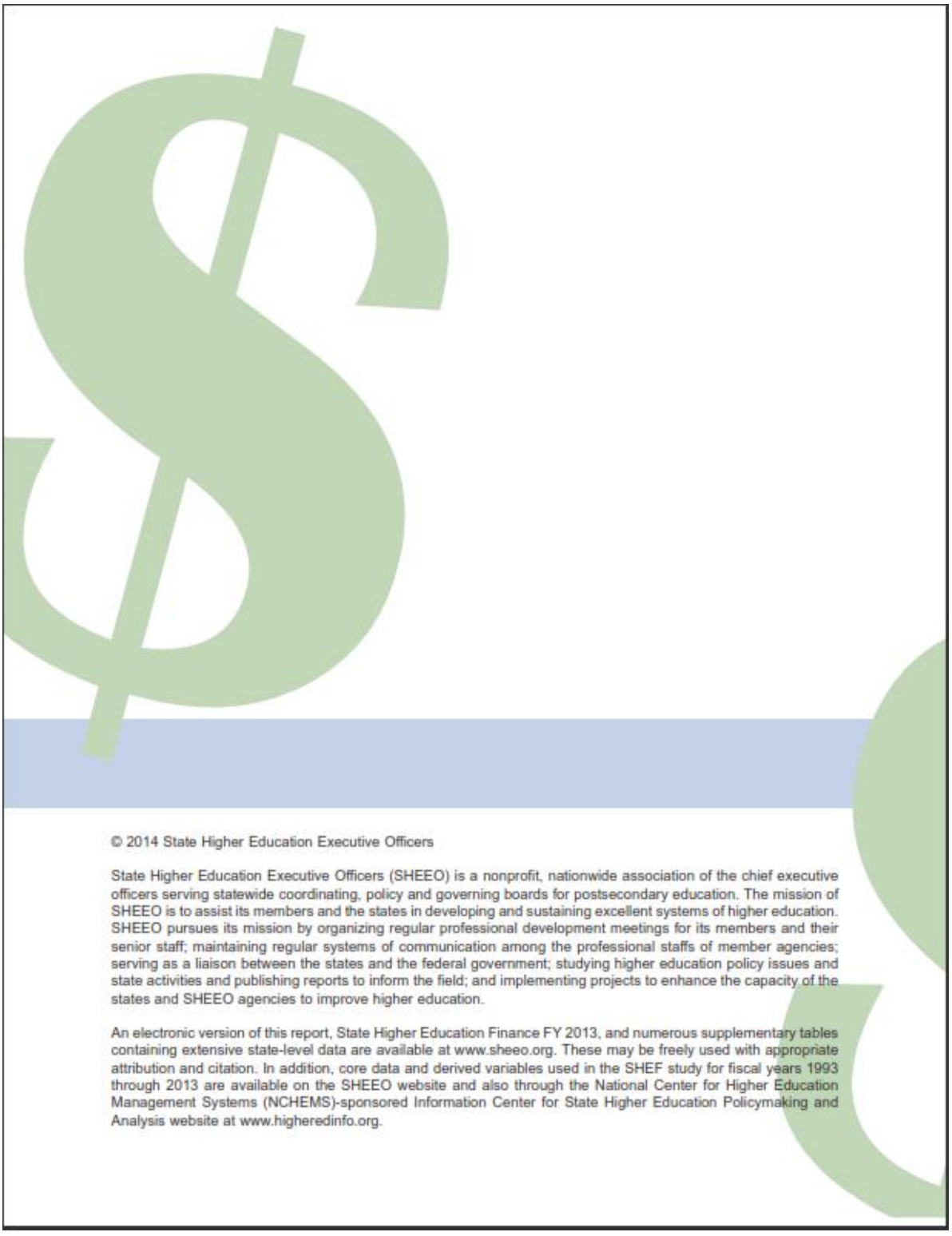
Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
CUNY Hunter College	0.00	42.42	58.62	42.16	34.44
CUNY John Jay College of Criminal Justice	0.00	13.63	57.13	0.00	13.57
CUNY Lehman College	0.00	14.79	44.46	0.00	14.80
CUNY Queens College	0.00	27.77	53.88	23.22	22.90
State University of New York at New Paltz	0.00	0.00	0.00	0.00	0.00
SUNY College at Brockport	0.00	6.50	0.00	0.00	1.61
SUNY College at Cortland	0.00	3.84	36.95	14.27	0.00
SUNY College at Oswego	0.00	0.00	36.68	26.53	0.00
SUNY College at Plattsburgh	0.00	1.98	21.91	7.34	0.00
SUNY College at Potsdam	0.00	3.77	24.15	7.48	0.00
Youngstown State University	0.00	18.02	19.62	25.80	0.00
East Central University	0.00	10.63	30.86	0.00	0.00
Northeastern State University	8.58	35.96	0.00	0.00	0.00
University of Central Oklahoma	0.16	13.09	77.71	0.00	0.00
Southern Oregon University	0.00	21.14	0.00	26.02	0.00
Bloomsburg University of Pennsylvania	0.00	6.18	0.00	47.55	2.83
California University of Pennsylvania	0.00	0.00	18.48	32.74	0.00
Clarion University of Pennsylvania	0.00	0.00	0.00	25.06	0.00
East Stroudsburg University of Pennsylvania	0.00	0.00	0.00	32.40	0.00
Edinboro University of Pennsylvania	0.00	5.67	0.00	11.14	0.00
Kutztown University of Pennsylvania	0.00	5.20	0.00	45.32	0.00
Millersville University of Pennsylvania	0.00	0.00	15.40	39.71	0.00
Shippensburg University of Pennsylvania	0.00	0.00	1.33	34.68	0.00
Slippery Rock University of Pennsylvania	0.00	0.00	0.00	25.87	0.00
West Chester University of Pennsylvania	0.00	20.73	0.00	46.99	3.47
Rhode Island College	0.00	19.32	21.55	10.42	0.00
Citadel Military College of South Carolina	0.00	24.76	0.00	68.06	28.97
Winthrop University	0.00	19.81	0.00	35.78	13.17
Austin Peay State University	0.00	24.20	0.00	0.00	16.76
Tennessee Technological University	0.00	13.72	0.00	7.24	0.00
The University of Tennessee-Chattanooga	0.00	18.44	54.39	0.00	0.00
Prairie View A & M University	0.00	0.00	4.33	1.15	0.00
Stephen F Austin State University	0.00	10.72	0.00	28.12	0.00
Sul Ross State University	0.00	0.00	40.99	18.41	0.00
Tarleton State University	0.00	17.47	55.96	15.91	0.00
Texas A & M International University	0.00	0.00	44.48	2.97	14.84
Texas A & M University-Texarkana	0.00	0.00	0.00	0.00	0.00

Institution	Input Variables (%)				
	x1	x2	x3	x4	x5
Texas State University	4.16	15.56	58.59	39.73	0.00
The University of Texas at Tyler	0.00	11.90	13.05	0.00	0.00
The University of Texas-Pan American	0.00	1.35	55.90	9.08	0.00
University of Houston-Clear Lake	0.00	11.68	22.76	0.00	0.00
University of Houston-Victoria	0.00	0.00	0.00	0.00	0.00
West Texas A & M University	0.00	0.00	66.84	20.49	0.00
Southern Utah University	0.00	0.00	64.96	0.00	2.34
James Madison University	0.00	30.36	52.16	63.49	8.54
Norfolk State University	0.00	0.00	70.11	34.71	0.00
Radford University	0.00	29.25	0.00	47.30	0.00
University of Mary Washington	0.00	30.87	0.00	47.33	0.00
Eastern Washington University	0.00	5.79	69.86	33.90	0.00
Western Washington University	0.00	9.10	19.87	48.10	0.00
University of Wisconsin-La Crosse	0.00	20.32	38.42	34.76	0.00
University of Wisconsin-Oshkosh	0.00	11.94	38.91	27.75	0.00
University of Wisconsin-Platteville	0.00	13.27	35.67	26.30	0.00
University of Wisconsin-Stout	0.00	3.53	40.71	22.74	0.00
University of Wisconsin-Whitewater	0.00	17.38	32.73	37.01	0.00
Marshall University	0.00	40.44	73.12	48.45	31.40

Input Variables: x1=undergraduates; x2=academic_staff_FTE; x3=admin_staff_FTE; x4=revenues; x5=expenditures

Appendix H

Permission to Use "Public FTE Enrollment and Educational Appropriations per FTE, U.S., Fiscal 1988-2013" in Figure 2 (SHEEO, 2014)



State Higher Education Executive Officers (SHEEO) is a nonprofit, nationwide association of the chief executive officers serving statewide coordinating, policy and governing boards for postsecondary education. The mission of SHEEO is to assist its members and the states in developing and sustaining excellent systems of higher education. SHEEO pursues its mission by organizing regular professional development meetings for its members and their senior staff; maintaining regular systems of communication among the professional staffs of member agencies; serving as a liaison between the states and the federal government; studying higher education policy issues and state activities and publishing reports to inform the field; and implementing projects to enhance the capacity of the states and SHEEO agencies to improve higher education.

An electronic version of this report, State Higher Education Finance FY 2013, and numerous supplementary tables containing extensive state-level data are available at www.sheeo.org. These may be freely used with appropriate attribution and citation. In addition, core data and derived variables used in the SHEF study for fiscal years 1993 through 2013 are available on the SHEEO website and also through the National Center for Higher Education Management Systems (NCHEMS)-sponsored Information Center for State Higher Education Policymaking and Analysis website at www.higheredinfo.org.

Appendix I

Institutional Review Board Documentation

September 12, 2014

MEMORANDUM

TO:	Blake Decker Michael Miller
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Submission
IRB Protocol #:	14-09-091
Protocol Title:	*Estimating the Efficiency of Four-Year Public Master's Universities in Arkansas using Data Envelopment Analysis*

In reference to the request for IRB approval of your project titled *Estimating the Efficiency of Four-Year Public Master's Universities in Arkansas using Data Envelopment Analysis*, the IRB is not authorized to oversee and approve such research. This protocol does not meet the definition of research involving human subjects in the federal regulations. (See the citation below.) You are free to conduct your research without IRB approval.

45 CFR 46.102 (f)

(f) Human subject means a living individual about whom an investigator (whether professional or student) conducting research obtains

(1) Data through intervention or interaction with the individual, or
(2) Identifiable private information.

If you have any questions do not hesitate to contact this office.