A TOOL KIT FOR BUILDING HBCU TECHNOLOGY TRANSFER SUPPLY CHAIN NETWORKS USING AN ADVANCED PLANNING SYSTEM

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ABSTRACT

This mixed methods study describes the development of a university technology transfer that Historically Black Colleges and Universities (HBCUs) can use to become more self-reliant financially. HBCUs lag behind their peer non-HBCUs because historically they have been under-served and were originally established largely as teaching and blue collar trade schools. Increased involvement in research oriented activities such as technology transfer will likely enable HBCUs to grow into new or stronger research institutions. The literature review revealed several problem areas with non-HBCUs university technology transfer include: (1) lack of quality standard benchmarks; (2) resource planning issues; (3) processing delays; and (4) need for improved intellectual property policies. These problem areas for non-HBCUs would be challenging for HBCUs as well. Despite these problems, the non-HBCUs are generating licensing revenues.

Systems dynamics is the process of combining the theory, method and philosophy necessary to analyze the behavior of a system in order to provide a common foundation that can be applied whenever it is desired to understand and influence how things change over time. Applying the systems dynamics approach, a theoretical framework comprised of tight linkages between the social comparison theory (Festinger, 1954), resource based view (Barney, 1991), Forrester's theory of distribution management related to supply chain management (Mentzer, 2001), and the paradigm-effect theory (Barker, 1992; Kuhn, 1996) was developed. This theoretical framework was used to research four (4) tools in an advanced planning system to address the four (4) non-HBCU technology transfer problem areas.

First, a benchmarking tool was developed for use by HBCUs to establish technology transfer quality standards. Second, a budget resource planning tool was developed using a linear programming optimization technique. Third, a tech transfer job scheduling tool

was developed using an advanced optimization technique. Fourth, a Model IP Policy tool was drafted.

Increased HBCU participation in tech transfer represents a paradigm shift. When old paradigms lose their effectiveness, one of the reasons leaders do not solve problems right away is the lack of technological tools (Barker, 1992). This toolkit is an advanced planning system to help HBCUs and other emerging research institutions better compete for licensing revenues.

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CHAPTER I
INTRODUCTION AND OVERVIEW

1.1 Problem Statement

Historically black college and university (HBCU) administrators have complained of being severely under-resourced and of a decline in financial support from government sources (Jones, 2013). This is a serious, pressing problem that needs closer attention. Some experts have argued that HBCUs are no longer relevant and should close their doors (John M. Lee Jr., 2013). HBCUs were primarily established to address unequal access to education and were primarily established as teaching institutions (Lorenzo L. Esters, 2013; Nia Imani Cantey, 2013). Per the Carnegie classifications of universities, few of the HBCUs are research oriented ("The Carnegie Classification of Institutions of Higher Education," 2016). Thus, few HBCUs are engaged in technology licensing for revenue generation. There has been an inability to adapt to change toward being more financially self-reliant (M. G. Williams, 2010).

The purpose of this mixed methods study was to develop a tool kit for university technology transfer that HBCUs can use to become more self-reliant financially. HBCUs lag behind their peer non-HBCUs because historically they have been under-served and were originally established largely as teaching and blue collar trade schools. Increased

involvement in these research oriented activities will likely enable HBCUs to grow into new or stronger research institutions. A comprehensive literature review of university technology transfer is needed to reveal non-HBCUs' technology transfer problem areas. The problem areas for non-HBCUs would be challenging for HBCUs as well. Thus, the non-HBCUs tech transfer challenges are likely to be part of the reason that HBCUs are not taking advantage of tech commercialization.

The proposed tool kit includes tools that will likely alleviate the problem areas with university technology in an effort to increase HBCU involvement in university technology transfer, industry partnerships, and tech-led business ventures. Informal communication networks are required to increase faculty engagement in tech transfer (D. Wright, 2013). Advanced planning information technology tools aid in advancing informal knowledge sharing networks which increase faculty engagement in tech transfer. They can improve decision making and perceived university tech commercialization service competencies and performance. Thus, with respect to advancing the participation of HBCUs in university tech commercialization, the research problems presented include:

1. Given that the problems that non-HBCUs face with university technology transfer will likely equally or more challenging for HBCUs, what are the problem areas with non-HBCUs' university technology transfer?
2. What theoretical framework for research can be used to develop advanced planning system tools to help HBCUs with technology transfer?
3. What advanced planning system tools should be developed and used by HBCUs to diminish the university technology transfer problems?

1.2 Proposed Solution

The primary goals of this study is to ascertain how HBCUs can improve their financial situation with the use of technology licensing to generate revenues. Many non-HBCUs have benefited financially from their research and technology transfer activities. In fact, university technology licensing has been used by research universities for more than 35 years in order to help them acquire increased research funding (E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999). Most of the university research center funding comes from external sources. Universities learn from their own experiences as well as the experiences of others (M. F. Feldman, Irwin; Bercovitz, Janet; Burton, Richard, 2002). Thus, HBCUs can learn from non-HBCUs.

HBCUs can learn from non-HBCUs that are engaged in technology transfer. However, there currently is no theoretical framework for researching HBCU technology transfer and how best to select which non-HBCUs to compare themselves to. Further, there is no theoretical framework that can be used to develop tools to help HBCUs establish quality standards for their university technology transfer programs; or to optimize their university technology transfer performance. The reasons why HBCUs are currently not engaging in tech transfer can be gleaned from research about non-HBCU tech transfer problem areas. Advanced planning system tools commonly used in industrial engineering can likely be used to address these problem areas.

1.3 Type of Study

This is a mixed-method exploratory study. The literature review is the qualitative method used unveil reasons why HBCUs may not find university technology transfer appealing. The literature review also explores theories that might prove helpful in the development of

a proposed HBCU tech transfer theoretical framework. Further, the literature review explores advanced planning system tools that can be used to alleviate university technology transfer problem areas.

1.4 Delimitations of the Study

Figure 1 is a study scope diagram which illustrates the boundaries of this study. The study is limited to American universities. There are Title III universities and there are non-Title III universities. The five (5) school categories defined in Title III of the Higher Education Act of 1965 include:

1. Historically Black Colleges and Universities (HBCUs)
2. Minority serving institutions (MSIs)
3. Hispanic serving institutions (HSIs)
4. Native American serving institutions (NASNTIs)
5. Asian American and Native American Pacific Islander-serving Institutions (AANAPISIs).

There are 102 accredited HBCUs reported by the United States White House Initiative on HBCUs ("White House Initiative on Historically Black Colleges and Universities"). However, in investigating HBCUs for this study, it was discovered that one of the 102 schools closed in 2013 (Hawkins, 2013); i.e. St Paul's College in Lawrenceville, Virginia. Thus, there are 101 HBCUs. Using the National Center for Education Statistics (NCES) database, non-HBCUs in these same states were identified. A list of the HBCUs and non-HBCUs is provided in Appendix A. The White House Initiative lists the HBCUs by state. Using this list, it was discovered that most of the HBCUs are located in 18 eastern and southeastern states as shown in Figure 2 map of HBCU locations.

Applying the social comparison theory, this study compares only the HBCUs that offer Doctoral degree programs to non-Title III universities that offer Doctoral degrees. This research uses mixed-methods in the sense that the literature review is used qualitatively to provide insight into how to select the non-Title III universities.

The social comparison theory can be used to help identify specific useful data about non-HBCU doctoral institutions which match lessons learned and criteria established by social comparison theory research. The data sources include the US Department of Education National Center for Education Statistics (NCES) database, Association of University Technology Managers' (AUTM) 2013 Annual Licensing Survey STATT database, US Patent and Trademark Office (USPTO) Patent Full Text (PatFt) database, and the National Research Council (NRC) faculty quality survey data. From the resource based view, non-HBCU resource characteristics can be gathered from these data sources and used to develop a benchmarking tool for HBCU representatives to use.

Since HBCUs are woefully behind non-HBCUs with respect to tech commercialization, it may be difficult for HBCUs to get a clear understanding of the norms used to establish a tech transfer operation. In particular, it is also the case that HBCUs are under significant strain due to their revenue generating capacity. Thus, having a benchmarking tool will help HBCUs with resource planning. This research is particularly interested in focusing on trying to understand which input factors impact on the quality of the revenue output of similar non-HBCUs.

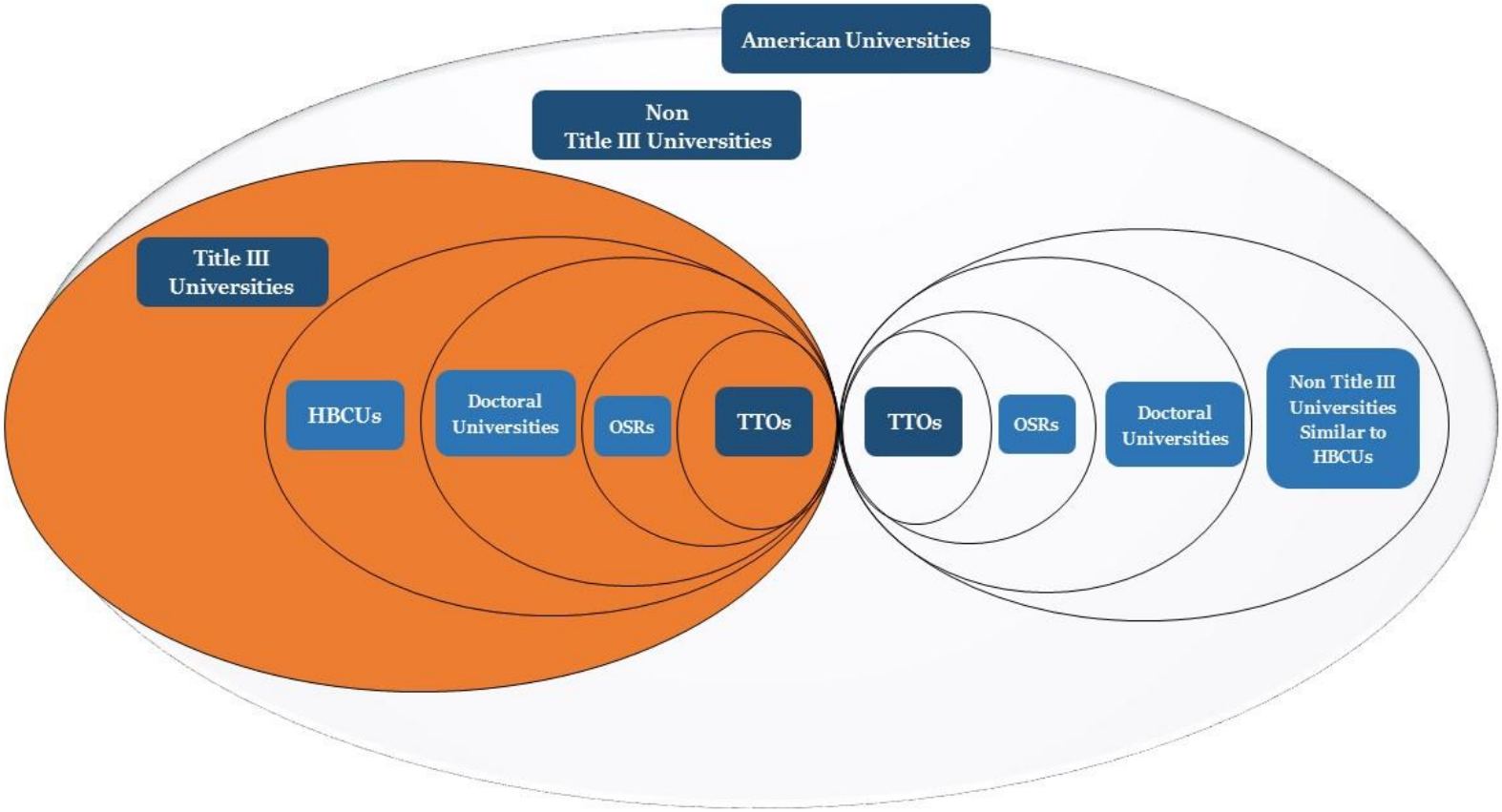


Figure 1. Study Scope Diagram



Figure 2. Map of HBCU Locations

Besides the social comparison theory, this study seeks to view university technology transfer as a supply chain network for which the theory of distribution management can be applied. Most of the research in supply chain management (SCM) addresses problems from a tactical standpoint. So, a major challenge is to increase research focused on the development of models for the strategic and tactical planning of SCM (Amaro, 2008).

Besides the proposed basic benchmarking tool, optimization and advanced optimization tools can be developed to address problems with university technology transfer and to level the playing field for HBCUs. When old paradigms lose their effectiveness, one of the reasons leaders do not solve problems right away is the lack of technological tools (Barker, 1992). Advanced supply chain planning addresses a host of decisions about the coordination, design and short term scheduling of supply chain processes (B. M. Fleischmann, Herbert, 2003). Applying the theory of distribution

management, the proposed toolkit was developed based on considering university technology transfer as a supply chain network enterprise from its suppliers to its customers and how its activities are inter-dependent. The literature review was used to uncover existing problems with tech transfer faculty engagement. It is proposed that these problems can be overcome with advanced planning system tools such as the linear programming optimization technique and advanced optimization; and recognition that a managed paradigm shift is required.

The next section provides definitions for the key terms used in this study.

1.5 Definitions of Key Terms

Herein this study, the following definitions of key terms are used:

Historically Black Colleges and Universities (HBCUs) – As per the Higher Education Act of 1965, a HBCUs is:

> "...any historically black college or university that was established prior to 1964, whose principal mission was, and is, the education of black Americans, and that is accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education] to be a reliable authority as to the quality of training offered or is, according to such an agency or association, making reasonable progress toward accreditation."("White House Initiative on Historically Black Colleges and Universities").

Non-HBCUs – any accredited university that is not a HBCU or any other Title III institute of higher learning.

Emerging Non-HBCUs – the accredited universities that are not HBCUs or any other Title III institute of higher learning which are selected for HBCUs to compare themselves to. These emerging non-HBCUs report their licensing revenues by submitting their completed the annual licensing surveys collected by the Association of University Tech Managers (AUTM); and are in the

lower quartile in licensing revenue earnings. This is evidence of their emerging ability to earn licensing revenues.

Emerging Research Institution (ERIs)– As defined by the Federal Demonstration Partnership (FDP) of the National Academies, emerging research institutions are institutions that are relatively new to managing federal funds whose federal research obligations for engineering and science to institutions of higher education are less than $20 million annually in federal R&D funding as listed in the National Science Foundation (NSF)'s National Center for Science and Engineering Statistics website (formerly, the Science Resources Statistics (SRS) website). ERIs are at least funded by two (2) federal FDP federal agencies (D. Wright, 2008).

The FDP is a program convened by the Government-University-Industry Research Roundtable (GUIRR) which is an organization housed in the Policy and Global Affairs Division of the National Research Council (NAS, 2012).

Research and Development (R&D) - R&D is organized research which includes both federal and other "sponsored research" activities and "university research" funded by an institution of higher education. As per the NSF:

> "Research is the systematic study directed toward fuller knowledge or understanding of the subject studied. Research is classified as either basic or applied, according to the objectives of the investigator. Development is systematic use of the knowledge or understanding gained from research, directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes" (NSF).

Invention - any art or way of making or doing or making things, design, improvement that is useful and new, composition of matter, machine or any plant variable that is patentable under federal patent laws (USPTO, 2016a).

Patent – an intellectual property right granted by the federal government to an inventor "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States for a limited time in exchange for public disclosure of the invention when the patent is granted" (USPTO, 2016a).

University technology transfer (abbrev. "tech transfer") – The Association of University Technology Managers (AUTM) defines university technology transfer as "the way scientific findings are transferred from one organization to another for the purpose of further development and commercialization". It is the process of using patents and copyrights to protect intellectual property, the development of marketing strategies, and licensing technologies to startups or existing companies (AUTM, 2016).

Commercialization - the way that new services and products enter the marketplace. Commercialization includes the initial introduction of the product, mass production, and consumer adoption. Commercialization includes the manufacturing, distribution, marketing, sales and customer support necessary for commercial market success. It begins with the development of a marketing plan, the method of market entry, and the anticipation of market entry and sustainability barriers (Investopedia, 2016a).

Intellectual Property (IP) - Creative works or ideas that the creator can share or allow others to copy and make through the concept of enablement. Intellectual property can be protected with trade secrets, trademarks, copyrights or patents (USPTO, 2016a).

Intellectual Property Licensing, Licenses – the transfer of intellectual property use or control rights from one entity to another with a contractual license agreement (Leute, 2010).

Equity Licensing – Equity is ownership in a business. A university can license intellectual property in return for cash or equity.

Royalties – payments made by a license to the licensor when the licensee sells products or services based on the intellectual property licensed from the licensor (licensed products) the company. Examples of royalties include a percent of net sales or a fixed amount of money per unit sold (Leute, 2010).

Social Comparison Theory - A social cognitive psychology theory developed by Leon Festinger in 1954 that states that individuals and groups satisfy their fundamental need for accurate certainty and cognitive limpidness by finding information about the accurate certainty of their opinions and the accuracy of their abilities by sizing themselves up to others (Jerry Suls, 2000).

Spinoffs – Small businesses which uses a university's faculty researchers and/or research results. A spinoff may get business formation, venture capital or other technical assistance support from the university. The university may license the use of a patent to the spinoff business for cash or equity ownership in the business.

Start-Ups – Small businesses which are newly started. Start-ups may not necessarily have the direct involvement of a university's faculty or student researchers. The start-up may get assistance from a university and/or licensing inventions from the university.

Resource Based View – a business strategy theory developed by Dr. Jay Barney in 1991 which advises the importance of firm resource internal endowments on the creation of competitive

advantages; and if resources are not imitable (i.e. so good or unique that they are impossible to copy), then they are sources of sustainable competitive advantage (Barney, 1991).

Sponsored Research Program Office (OSP) – Several universities have a designated office to provide assistance with managing government and industry sponsored (i.e. funded) research.

Tech Transfer Office (TTO) – Several universities have a designated office to provide tech transfer services to university faculty and student researchers. The TTO staff is responsible for training university researchers about laws and university policies. The TTO staff also solicits invention disclosures, evaluates the disclosures, seek patent protection, handles patent maintenance fees, negotiates licenses and handles licensing royalty payments. TTOs may be called Tech Licensing Offices (TLO) or Intellectual Property Offices (IPOs) or other names. The names vary among the universities. But, the acronym TTO is frequently found in scholarly literature.

TTO Store – a novel term coined in this study which views the TTO as a store which commercializes patented inventions and other university owned intellectual property as "goods". The TTO is viewed as a supplier of goods that customers demand.

Distribution Management – The process of overseeing and controlling how products move from suppliers or manufacturers to sales destinations. Distribution management includes the activities and processes for packaging, storing, and moving products in the supply chain with logistics (Investopedia, 2016b)

Theory of Distribution Management – A business management theory that because institutions are so interweaved, system dynamics impacts the function of product research, engineering, sales and promotion (Mentzer, 2001). In 1958, Forrester introduced the theory of distribution management by using a computer simulation to describe product order information flow and how

this influenced the performance of production and distribution (Mentzer, 2001). Forrester's theory of distribution management is a system dynamics idea applied to production distribution noted in Forrester's 1961 book *Industrial Dynamics* (Forrester, 1961).

Supply Chains, Supply Chain Management (SCM) and Supply Chain Networks - A supply chain is a network of steps required to move products or services from the supplier/ manufacturer to the customer. Management of the supply chain typically involves reducing costs with optimization. The supply chain network includes the producers, handlers and distributors of products (Investopedia, 2016c). This management concept was first referred to by Dr. Jay Forrester in 1958 (Mentzer, 2001). The actual acronym SCM was used by Oliver and Webber in 1982 (Corominas, 2013). SCM gained popularity in the 1990s due to global sourcing's emphasis on time and quality competition (Kumar, 2001; Mentzer, 2001).

System Dynamics –the process of combining the theory, method and philosophy necessary to analyze the behavior of a system in order to provide a common foundation that can be applied whenever it is desired to understand and influence how things change over time (Forrester, 1993). The father of System Dynamics is Dr. Jay Forrester.

Paradigm-effect theory – In 1962, physicist Dr. Thomas Kuhn introduced the concept of the 'paradigm shift' as related to certain scientific work. Kuhn taught that certain scientific work provides a resourceful framework of concepts, results, procedures, and traditional practices for which subsequent work is structured and follows. This lasts only for a time and then shifts (Kuhn, 1996). The paradigm-effect theory is that it is difficult to notice the need for the shift when an existing paradigm is very strong. This leads to paradigm paralysis. A related business strategy theory which applies Kuhn's philosophy of science was developed in 1992 by Joel Barker which states that organizational leaders can learn to anticipate the future better rather than fear it by

learning strategic exploratory skills that help them notice and manage needed paradigm shifts (Barker, 1992).

Advanced Planning System – A supply chain management information technology system that relies on historical demand data to forecast and manage future demand (B. M. Fleischmann, Herbert, 2003). These systems include optimization techniques, forecasting and scenario planning that provide what-if analyses and simulation (Kumar, 2001). Herein this study, the emphasis is on optimization techniques used for business management purposes. These systems range from simple to complex.

Optimization techniques – mathematical programming used in operations research to maximize or minimize an objective function subject to linear, nonlinear, and integer constraints (Dantzig, 1997). Linear programming is an optimization technique that consists of maximizing or minimizing a linear objective function by systematically choosing input values from within an allowed set and computing the value of the function. In 1947, Dr. George Dantzig developed the simplex algorithm for linear programming which is widely used today (Dantzig, 1997).

Advanced Optimization techniques – a class of numerical challenges that surface in statistical inference. When it is not possible to calculate the estimators related to a given paradigm, the computer generated random variables that have a distribution yields a way to get solutions for statistical challenges. General solutions are found using simulation (Robert, 2010). Metaheuristics and stochastic methods are examples of advanced optimization techniques.

Heuristic, Meta-Heuristic – A heuristic is part of a search algorithm in computer science. A meta-heuristic is a high level search procedure that provides an optimal solution to an optimization problem within a reasonable time (Zapfel, 2010).

1.6 Proposed Study

This study applies a mixed method approach. While some scholars believe that a literature review is not research, in this mixed method study, the literature review is used to provide qualitative data about problem areas in non-HBCU university technology transfer which informs the empirical investigation of solutions to alleviate these problems. Qualitative data is also used to compare HBCU doctoral institutions to select non-HBCU doctoral institutions. This research study expands three (3) streams of Industrial Engineering Management literature. The first is relevant to regional economic and workforce development. The second is focused on the development of technological innovations relevant to potential industry partners and the management of such technological innovations. The third is focused on diversity in STEM education as related to workforce development.

In industrial engineering, the conversations in these three (3) areas are taking place in trade organizations such as the Institute of Industrial & Systems Engineers' (IISE) Society for Engineering and Management Systems (SEMS), American Society of Engineering Managers (ASEM) and the American Society of Engineering Education (ASEE). Outside of industrial engineering, the conversations take place in the Institute of Electrical and Electronics Engineers (IEEE) Technology and Engineering Management Society (TEMS), and Academy of Management (AOM) Technology and Innovation Management Division. Relevant scholarly journals include, but are not limited to the Industrial Management, Journal of Enterprise Transformation, Engineering Management Journal, and the Journal of Engineering Education. There has been very little published related to HBCUs. Only one journal article was found in a IEEE conference proceeding entitled "Developing an SSME Initiative for Instruction and Research at Morgan State University" regarding the Service Science, Management and Engineering (SSME) multi-disciplinary research about the integration of legal sciences, social cognitive sciences, information technology, operations research, management sciences, business strategy, and engineering (Thomas, 2008).

Thus, this dissertation research study will expand the body of literature related to the role that HBCUs play in industrial engineering.

1.6.1 Regional economic and workforce development

American slavery persisted between 1619-1865 (Juan Williams, 2004). The American Civil War over whether or not to continue the institution of slavery in American was from 1861-1865. When slavery ended, 4.4 Million freed slaves needed to be educated (M. G. Williams, 2010) and HBCUs were founded. There was government assistance from Freedmen's Bureau (Juan Williams, 2004), charity from the American Missionary Association (AMA), and charity from industrial philanthropists. These philanthropists lead industrial corporations which utilize industrial engineering practices.

From the beginning, the development of HBCUs has been relevant to industrial titans. Titans of industry provided charity to HBCUs because they wanted a say in how the former slave laborers would be educated since they had a continued need for this labor force. The industrial titans included, but were not limited to:

- Investor George Peabody (1867 Peabody Fund),
- Textile tycoon John Slater (1882 Slater Fund),
- John D. Rockefeller (1902-1964 General Education Board (GEB) for rural schools and the modernization of farming),
- Sewing machine tycoon Thomas White, and
- Sears Roebuck's Julius Rosenwald (Juan Williams, 2004; Thelin, 2009).

This dissertation research study is focused on uncovering problem areas in university technology transfer and creating an advanced planning system tool kit to assist HBCUs with alleviating these problems in order to improve their potential tech transfer performance. Improved university tech transfer performance will likely increase intellectual property licensing revenue generation, as proven by several non-HBCUs over more than 30 years, and will help HBCUs survive financially.

The survival of HBCUs is important to their local and regional economies. During interviews with HBCU presidents, they reflected on the HBCUs deeply ingrained public service and outreach missions and stressed the critical role the HBCUs play in educating underserved racial and ethnic minorities, economically disadvantaged individuals, rural or farm-based citizens, and first-generation students (Esters & Strayhorn, 2013). The survival and growth of HBCUs using a research orientation and university technology commercialization capabilities has very little coverage in the current body of literature. This proposed research will expand the current body of literature.

1.6.2 Development & management of technological innovations

Another body of research in engineering management is the development of technological innovation and management of engineering innovations. The management of university inventions through the technology transfer process is related. University research results stem from government and industry research funding. Technology transfer is crucial to industry partnering and the management of the inventions that result from such partnerships is very important. Currently, very little has been written about HBCUs involvement in such technology transfer other than the fact that there is currently very little engagement. Thus, this research will shed light on this problem and will serve to encourage HBCUs leaders, managers and faculty to get involved or more involved in the technology commercialization process.

1.6.3 Diversity in STEM education as related to workforce development

As noted, since Reconstruction, HBCUs have played a critical role in educating underserved racial and ethnic minorities, economically disadvantaged individuals, rural or farm-based citizens, and first-generation students (Esters & Strayhorn, 2013). This dissertation research is focused on the survival and growth of HBCUs. The survival of HBCUs is critical to the continued goal of increasing diversity in STEM education which is of vital importance to engineering education including industrial engineering education.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction

The passage of the National Land Grant Colleges Act (aka the Morrill Land-Grant Act) of 1890 led to the creation and funding of seventeen (17) public HBCUs (John M. Lee Jr., 2013; Juan Williams, 2004). Today, HBCUs represent about three (3) percent of American colleges. They enroll 12% of all Black university students and graduate 23% of all Black college students. Remarkably, this small group of colleges graduate 40% of all STEM related degrees and 60% of the engineering degrees black students earn (Bagley, 2013). HBCUs produce 17% of black with undergraduate degrees in health professions, 18% in engineering, 31% in math, and 31% in biotech (Clay, 2012).

Lorenzo et al. interviewed six (6) of the original HBCUs' presidents (Lorenzo L. Esters, 2013). These "HBCU presidents frequently referred to public land-grant HBCUs, as "the people's universities", reflecting their deeply ingrained public service and outreach missions… In many ways, the mission undergirds presidents' strategic decisions regarding what will take place on campus, how resources will be used, and how best to serve external constituents" (Lorenzo L. Esters, 2013). The presidents also stressed the critical role the HBCUs play in educating

underserved racial and ethnic minorities, economically disadvantaged individuals, rural or farm-based citizens, and first-generation students.

The relevancy of HBCUs has been an issue as some believe that since HBCUs promote racial segregation. Further, unlike the few opportunities available to blacks in 1890, today African Americans are not limited and attend all universities now. When states seek budget cuts due to the increasingly scarce funding for higher education, HBCUs are often threatened. In addition, with respect to accountability, HBCUs' performance has been criticized with the use of measures used to evaluate all universities (John M. Lee Jr., 2013).

Many HBCUs hold strong teaching histories and the imbalance of teaching, research, and service may be preventing HBCU success. Heavy teaching loads and the lack of research accountability may place research as a lower priority (Nia Imani Cantey, 2013). Cantey et al. noted that the HBCUs need to foster cultures of scholarly excellence with more demonstrated commitment to research production and collaboration. This research team suggests that HBCUs need to "offer research brown bags, writing groups, accountability groups, research grants and peer mentoring awards" (Nia Imani Cantey, 2013). Herein, it is proposed that much more is required.

As aforementioned, this research study is exploratory. Figure 3 provides a schematic of this study's comprehensive literature review journey. Section 2.1 presents the state of affairs of HBCU finances. Section 2.2 discusses university tech transfer's revenue potential. It provides the state of affairs of non-HBCU tech transfer and the state of affairs of HBCU technology transfer.

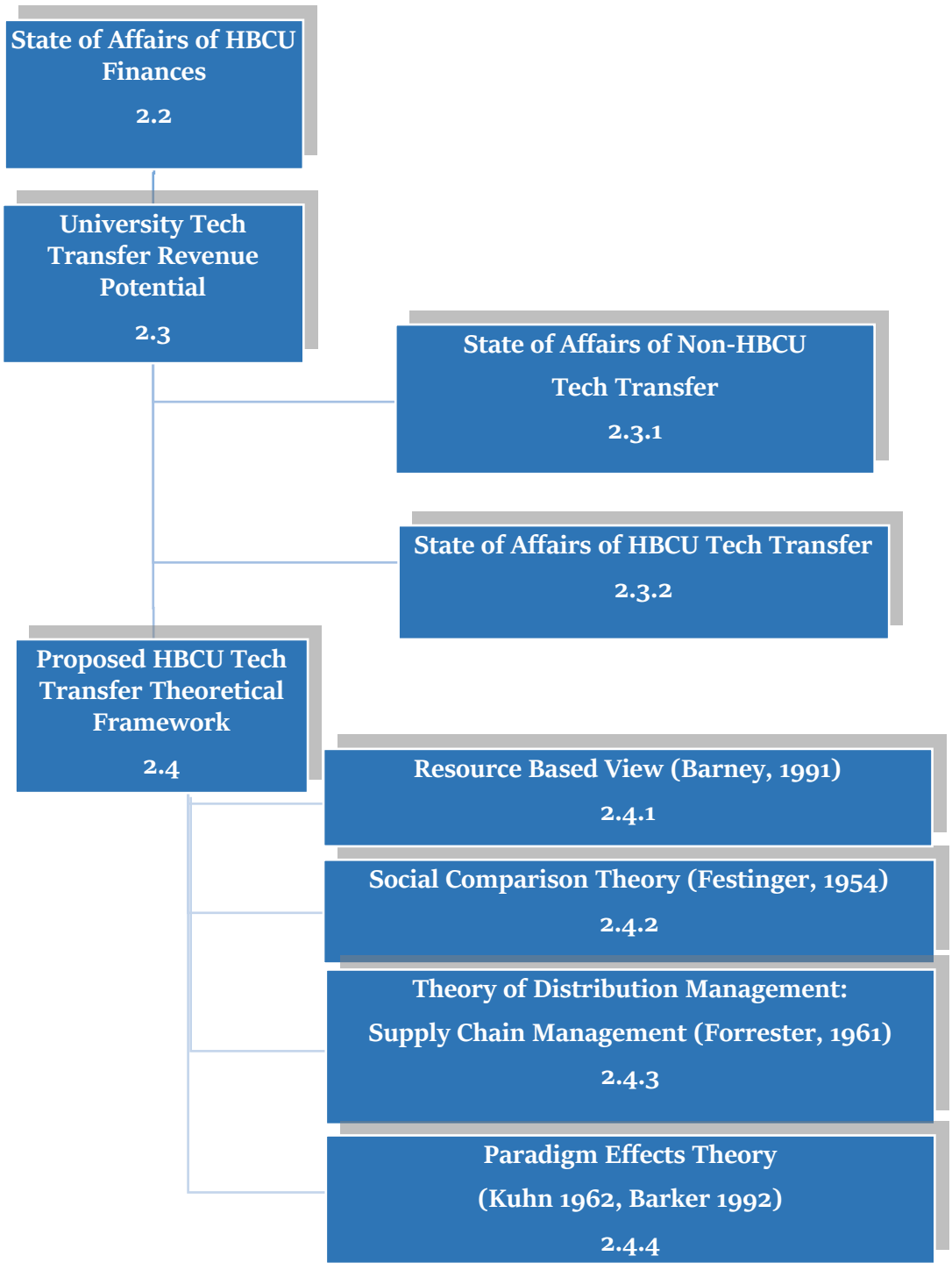


Figure 3. Literature Review Journey

Next, the potential theoretical framework for the proposed HBCU technology transfer research is explored. Section 2.3 provides a review of four (4) relevant theories: (1) the resource based view, (2) the social comparison theory, (3) the theory of distribution management (aka supply chain management), and the (4) paradigm-effect theory.

In order to explore how the resource based view theory applies to university technology transfer, a literature review of the specific resource inputs is discussed followed by a discussion of the performance outputs in the university tech commercialization process. These outputs are performance outcomes which include university intellectual property licensing and start-up business formation.

Given that HBCUs are not likely to be able to perform as well as larger more established research institutions, the social comparison theory is explored. This theory provides lessons on what types of schools the HBCUs should target and compare themselves to. It also provides information regarding the manner of comparison, that may motivate the HBCUs to engage in this proposed paradigm shift toward increased technology transfer activities. The resource inputs and outputs provide the framework for viewing university tech transfer as a supply chain network. This is a novel perspective and it requires an exploration of the theory of distribution management and the paradigm-effect theory.

Finally, a summary of the literature review findings is provided along with a gap analysis. Based on the gap analysis, the research questions for this study is presented.

2.2 State of Affairs of HBCU Finances

Following the Civil War, four million four hundred thousand (4.4 million) black slaves were freed in 1865 and could legally pursue education (Juan Williams, 2004). During Reconstruction, the Freedmen's Bureau was to move the newly freed slaves toward self-sufficiency. The American Missionary Association (AMA) and Freedmen's Bureau sent field representatives, teachers, money and supplies to help former slaves establish colleges such as Talladega College, Atlanta University and Morehouse College in 1867. Northern philanthropic foundations with close ties to big industry favored industrial and mechanical vocational curricula over liberal arts. In 1902, John D. Rockefeller Sr. and John D. Rockefeller Jr. established the General Education Board (GEB) of philanthropists which gave over sixty three million dollars to HBCUs between 1903 and 1964 (R. R. E. Charles V. Willie, 1978; Marybeth Gasman, 2008).

Industry wanted to train their future labor force. HBCUs were initially funded by wealthy northerners, aid societies and the Freedmen's Bureau. This waned by 1873. States took over many of these schools. For example, in 1871, Atlanta University received $8,000 per year from the Georgia legislature (Juan Williams, 2004). According to the U.S. Department of Interior, in 1896, 25.9 percent of the sources of income for black colleges came from state and municipal governments; 54.7 percent from private sources; 11.1 from tuition and fees; and 8.2 percent from endowment funds (R. R. E. Charles V. Willie, 1978). By 1915, fifty (50) percent of the sources of income were state funded. In the late 1930s due to the Great Depression, funding from the industrial philanthropists waned. In 1944, led by the president of Tuskegee Institute, 29 black colleges jointly raised funds and created the UNCF (Marybeth Gasman, 2008).

In 1969, HBCUs received a mere three (3) percent of the total federal funds granted to American schools of higher education (Thompson, 1973). At the time, the HBCUs enrolled three (3) percent

of the college students nationwide. Yet, the low funding level was arguably an unfair amount for the following reasons:

- the students were the most economically deprived and required special assistance in order to be able to adequately compete;
- the HBCUs had few wealthy alumni; and
- the HBCU philanthropic foundation and industry support waned (Thompson, 1973).

From 1970 to 1975, state government funding accounted for 69.7 percent of the HBCU funding (R. R. E. Charles V. Willie, 1978); and in 1975, federal funding was at 38 percent (Garibaldi, 1984). Beginning with President Carter in 1980, each U.S. president has providing federal funding to HBCUs (Marybeth Gasman, 2008). The Clinton Administration awarded $13 million to 29 HBCUs and mandated federal assistance from all federal departments and agencies under Executive Order 12876 (Grimes_Robinson, 1998). Five (5) percent of federal grants and contracts awarded went to HBCUs. HBCUs became increasingly dependent on government funding.

A historical timeline of HBCU societal perspectives is provided in Figure 4. It shows the timeline of HBCUs' dependence on the white paternalism of industrial philanthropists, periods of immense segregation, movements toward integration and the current period of American de-racialization where race is not supposed to matter as much (Allen, 2002).

Despite notions of de-rationalization, early in the 21st century, HBCUs continued "to be more financially dependent on government funding than most other colleges and universities" (M. Christopher Brown II, 2004). With increased integration and de-racialization, HBCUs are viewed by some as proponents of reverse discrimination because they have predominantly Black student and faculty bodies.

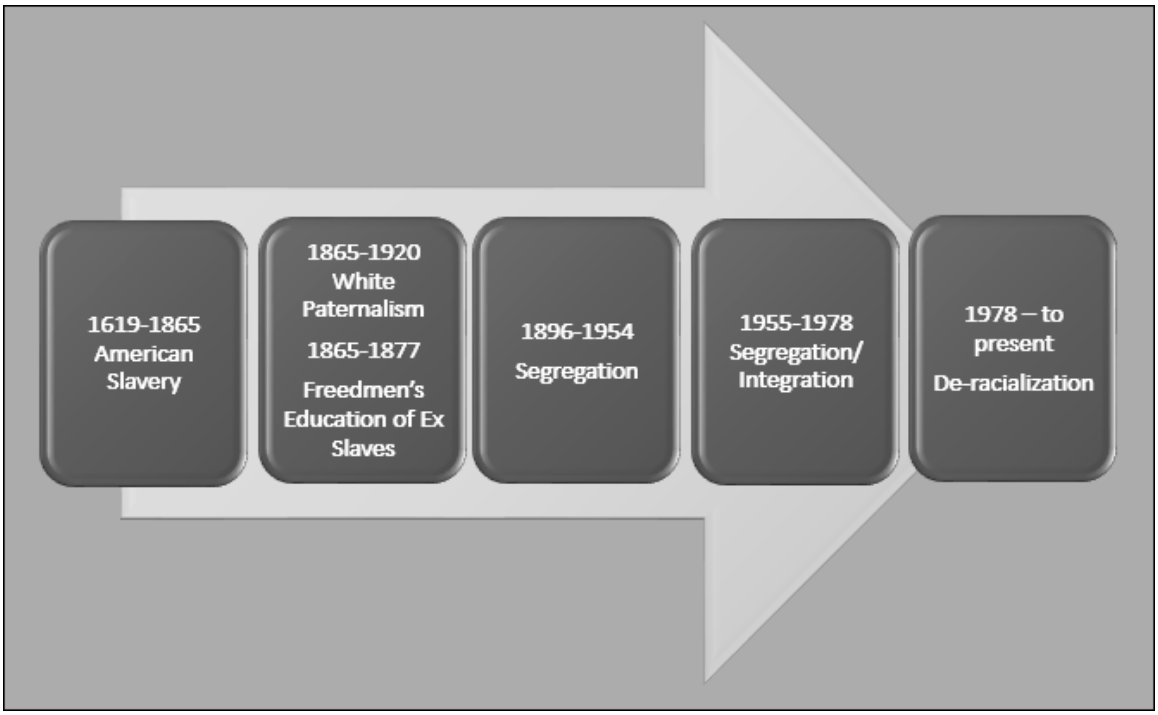


Figure 4. HBCUs' Historical Timeline of Societal Perspectives
Source: (Allen, 2002)

HBCUs continued to face overwhelming financial challenges such as endowments which are significantly lower than their non-HBCU counterparts and declines in tuition revenues due to growing recruitment competition from the non-HBCUs (R. J. R. Charles V. Willie, Ronald Brown, 2006; Juan Williams, 2004). Private HBCUs relied on tuition to pay 54% of their expenses; and the remainder came from federal funding, corporate sponsors and the United Negro College Fund (UNCF) (M. Christopher Brown II, 2004).

Today, each fall, the annual U.S. News and World Reports (USNWR) university rankings entitled "America's Best Colleges" are released. Seventy-five percent (75%) of each performance ranking covers six (6) areas including financial resources (Jones, 2013). HBCUs have underperformed in

financial resources in comparison to institutions with a majority of white students. The growth of financial resources will help improve HBCUs' reputations (Jones, 2013).

A proposed solution to the HBCUs' financial woes is that HBCUs must get creative and find ways to get donations from their alumni, corporations and foundations (Lorenzo L. Esters, 2013). Fundraising has been touted as the "most important factor" for the sustainability of HBCUs in the long term (Gasman, 2013).

Wealthy blacks such as Oprah Winfrey, Bill Cosby, Sean Combs, Tom Joyner, Steve Harvey, James Gilliam, and Willie Gary have made hefty contributions to HBCUs (Juan Williams, 2004). When wealthy backs give to non-HBCUs, some have been criticized by HBCU leaders (Stroud, 2014). It is viewed as an opportunity for HBCUs to pitch to celebrities what their research expertise and capabilities are in order to increase awareness.

Corporate sponsors such as Coca Cola, Procter & Gamble and Microsoft also provide scholarships (Juan Williams, 2004). However, the HBCU alumni give less than non-HBCUs because there are more whites in America and white Americans earn more (Juan Williams, 2004; M. Christopher Brown II, 2004).

Dealing with fiscal issues and fundraising is the responsibility of HBCU presidents (R. J. R. Charles V. Willie, Ronald Brown, 2006; Juan Williams, 2004). The HBCU presidents that Lorenzo et al. interviewed "candidly expressed that they are often working with very limited financial resources (i.e., shrinking budgets) while facing increased demand for higher education from Black and non-Black students who desire to attend their college. Additionally, our presidents explained that educating individuals with very few resources creates an alumni base that also has limited resources" (Lorenzo L. Esters, 2013). Although it is critical to develop a fund raising plan, in order to get major gifts, many HBCU leaders need to better cultivate relationships with funding sources.

HBCU leaders need to get more comfortable telling the university's story, articulating their needs, and making the case for financial aid (M. G. Williams, 2010).

Although most HBCUs struggle, some HBCU presidents have boded well in the fund raising arena (R. J. R. Charles V. Willie, Ronald Brown, 2006) including:

- Dr. William Harvey – Hampton University;
- Dr. Walter Massey – Morehouse College;
- Dr. Johnetta Cole – Spelman College; and
- Mary McLeod Bethune – Bethune Cookman University (who sold pies).

HBCUs must also network with government agency representatives in order to improve their chances of increasing their government research funding (John M. Lee Jr., 2013). Some HBCU leaders are insufficiently prepared in the budgetary and financial management of government funding and some have loss government funding due to inadequate accounting procedures (R. J. R. Charles V. Willie, Ronald Brown, 2006).

By the mid-1980s, HBCUs were receiving very little income from grants and research programs (Garibaldi, 1984). HBCUs were receiving federal Title III program funding for programs other than research and public service (Garibaldi, 1984). "This situation will change only when the colleges become actively involved in the political process to ensure that their vital interests are being considered" (Garibaldi, 1984). Thus, lobbying, understanding government funding programs, and getting training in government grant and contract proposal writing is crucial. Besides serving as a source of income, federal research financial support is closely related to research faculty productivity as defined by publications and presentations (Betsey, 2008). Publications and presentations contribute to prestige influence.

Besides improving financial resources, some argue that HBCUs need to address whether they have a clear and adequate vision; whether they understand competitive threats and lack of competitiveness; and whether they have adequate leadership and strategic positioning (America, 2012). Since faculty at HBCUs are more engaged in teaching, they receive far less research grant and contract funding (M. Christopher Brown II, 2004).

The truth is that there has been federal funds for HBCUs that go unused because some HBCUs lack the infrastructure to submit proposals and manage the funding administratively (Toni Coleman, 2010). In alignment with lack of understanding, some HBCU leaders simply do not understand the importance of having a solid research administration infrastructure and these HBCUs may continue to view teaching as their number one priority (Toni Coleman, 2010).
The next Section 2.2 is an exploration of whether or not active participation in university technology commercialization may be a great way for HBCUs to increase their revenues and become less reliant on external funding. University technology transfer is also known as university technology commercialization. It is the process of taking research results, applying for patent protection, and licensing them to well established companies or start-up businesses (using negotiated legal licensing agreements - i.e. contracts) in order to commercialize inventions as viable consumer products. The Bayh Dole Act of 1980 gave universities ownership of research results developed with federal funds and advised universities to participate in the technology transfer process ("Bayh Dole Act," 1980). In 2005, researchers found that an increase in industry research funding is a result of the implementation of the Bayh Dole Act; and the probability that increased patenting leads to increased research funding (Dai, 2005). For the past 34 years, few HBCUs currently take full advantage of this opportunity.

2.3 University Technology Transfer Revenue Generation Potential

In this section, as illustrated in Figure 5, scholarship related to the state of affairs of non-HBCU technology transfer is reviewed. This is followed by a review of the state of affairs of HBCUs' technology transfer for a comparison.

2.3.1 State of Affairs of Non-HBCU Tech Transfer

The Bayh Dole Act allows universities to retain ownership of inventions created with the use of federal research funding ("Bayh Dole Act," 1980). Many of these offices have actively attempted to license inventions since the Bayh Dole Act ("Bayh Dole Act," 1980). Sixty four highly ranked research universities reported that between 1991 and 1997, their licensing more than doubled from 938 to 1,923 by 1998 (J. B. Powers, 2003). Per the General Accounting Office (GAO), annual revenue from these patent licenses increased from approximately 160 million USD in 1991 to 611 million USD in 1997. This was approximately 2.5% of America's university R&D funding (D. S. Siegel, Waldman, David, Link, Albert 2003a).

As shown in Figure 6, according to the Association of University Technology Managers (AUTM), there were 4,932 licenses executed by universities in 2005 (AUTM, 2014c). There were 5,039 intellectual property licenses executed by universities in 2008 (AUTM, 2014b). There was a decline in 2011 to 4,899 in the number of licenses executed by universities (AUTM, 2014a). Yet licensing revenues for many research universities increased as much as two-fold. It can be inferred that the quality of licensing deals has improved.

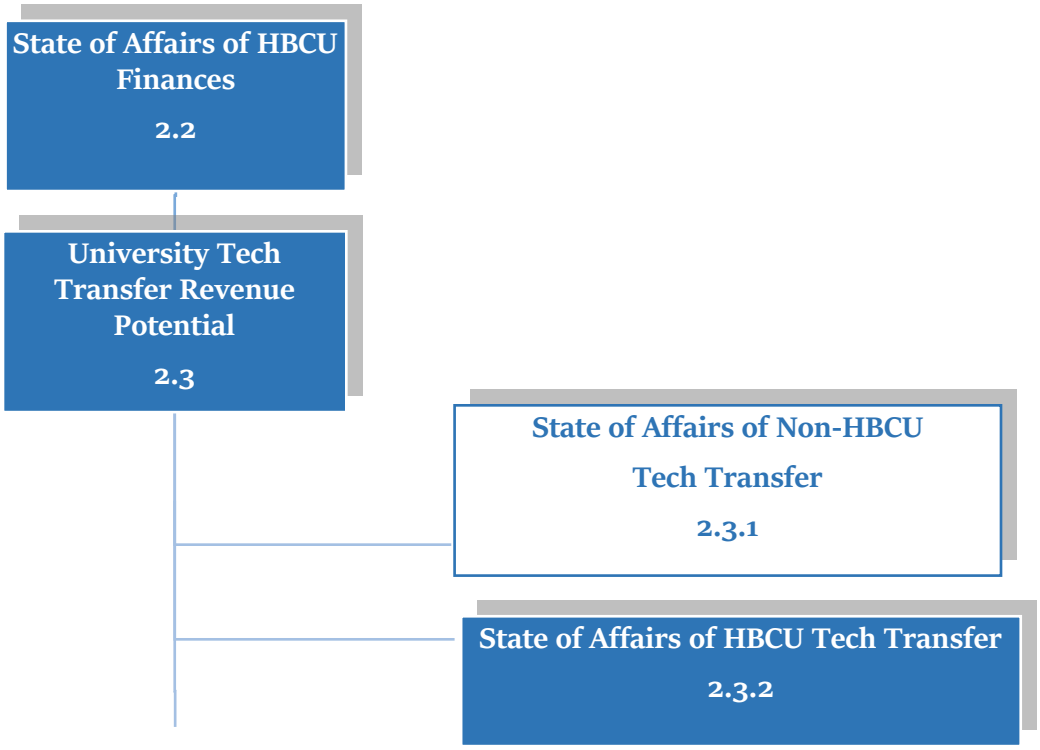


Figure 5. Literature Review Journey: non-HBCU Tech Transfer § 2.3.1

Siegel et.al. visited five (5) research universities and interviewed 55 scientists and administrators. These five (5) schools had below average licensing revenues. They also studied 113 universities not including the highly successful MIT, Harvard, Stanford and UC Berkeley. Siegel et al. concluded that although several university technology transfer offices struggle with "increasing" their licensing revenues (D. S. Siegel, Waldman, David, Link, Albert 2003a) they earned licensing revenues. In fact, the total gross licensing revenues for US universities from 1991-2014 are shown in Figure 7. The median central tendency is $1.061 Billion.



Figure 6. Licenses Executed 2005, 2009, 2011– Source: AUTM Annual Surveys

2.3.2 State of Affairs of HBCU Tech Transfer

In this section, as illustrated in Figure 8, a literature review of scholarship related to the state of affairs of HBCU tech transfer is provided.

HBCUs were woefully behind non-HBCUs at the onset because they had the challenge of educating ex-slaves who were illiterate. "[A]ttempts at higher education may have been beyond the bounds of the newly emancipated" (Peeps, 1981). Although the HBCUs were called "colleges", many

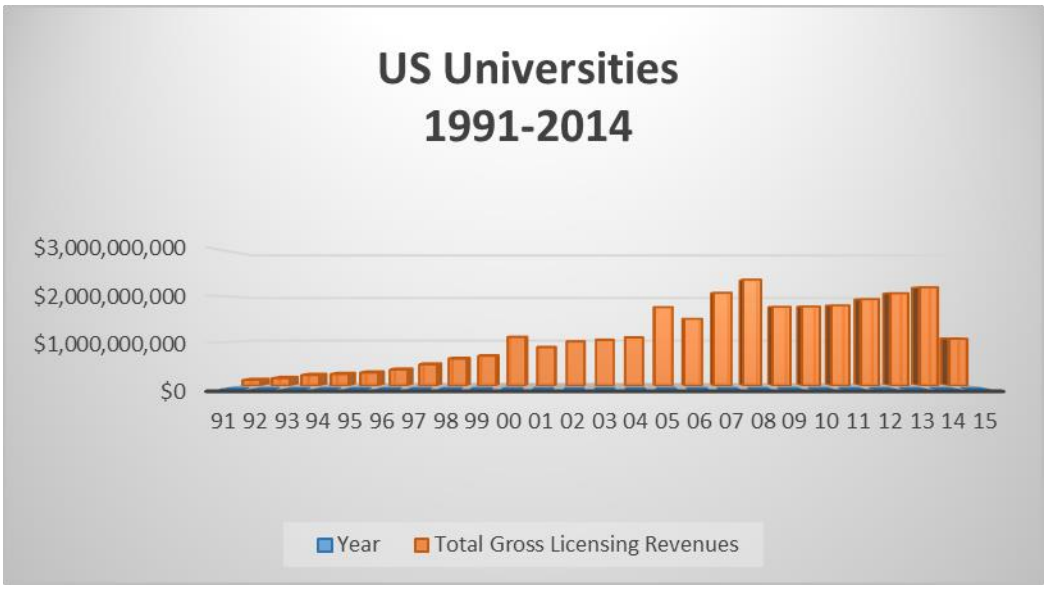


Figure 7. **Total Annual Licensing Revenues US Universities: 1991-2015**
Sources: AUTM STATT Database ("AUTM STATT Annual Subscription," ; C. Hamilton, Schumann, D., 2016).

taught students at the elementary school level. At the onset of HBCUs existence, the training of teachers was advocated because white southerners in particular did not want to instruct black students (Kujovich, 1993-1994). Although the college students were taught vocational trades, few actually went to work in factories. The college educated became trades teachers (Butchart, 1988). Southern slave owners did not educate their black slaves and as many as 96% were illiterate (Peeps, 1981). They feared and disbelieved in black education (Butchart, 1988). With respect to post slavery black sharecropping, white southerners feared an educated black labor force that could understand math, interest rates, and business accounting. If literate, the black sharecroppers could not be taken advantaged of and educated blacks was viewed as a liability to the sharecropping system (Butchart, 1988).

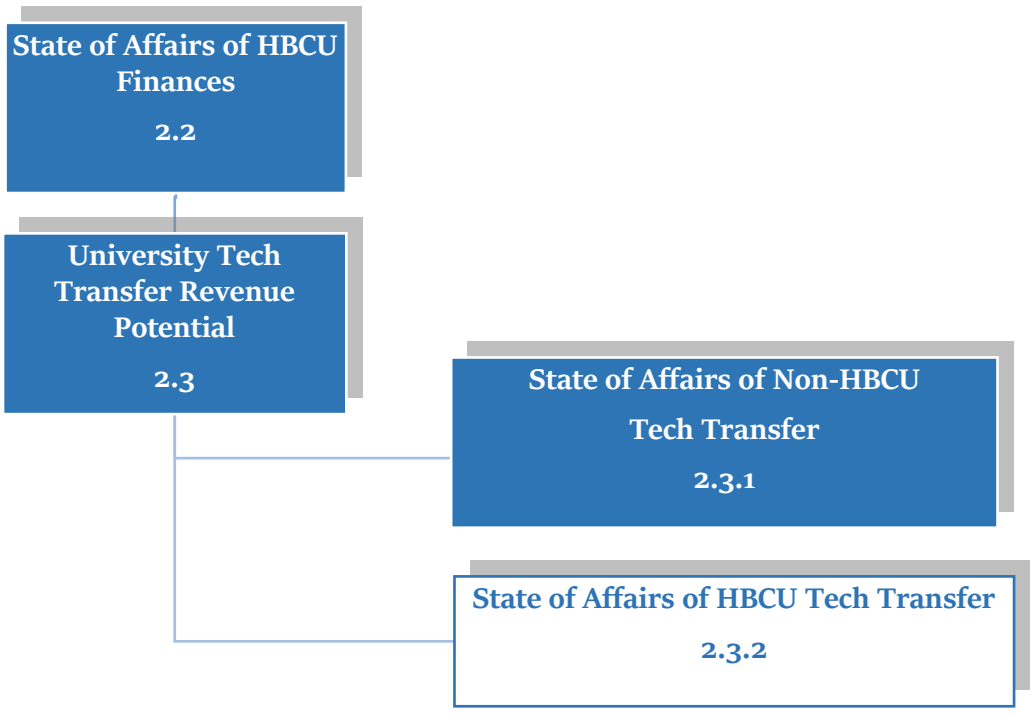


Figure 8. Literature Review Journey: HBCU Tech Transfer § 2.3.2

On the one hand, many southerners wanted to promote a caste system of white supremacy. Thus, most states provided little financial support to the HBCUs. Prior to the World War II, many of the HBCU facilities' conditions were horrible and dilapidated. There was little or no equipment (Kujovich, 1993-1994). In Mississippi by 1910, black classrooms averaged 67 students and black teachers were paid less than half the amount that white teachers earned (Butchart, 1988).

HBCUs were never created with the intention as serving a research function. They were originally controlled largely by white philanthropists who promoted vocational trades and liberal arts. When the Hatch Act of 1887 initiated federal research support at land grant universities, each state was to establish experiment stations for agricultural research and related curriculum development and graduate level work (Kujovich, 1993-1994). Experiment stations at the black land grants were practically nonexistent for more than 50 years after the Hatch Act was enacted despite the fact

that blacks were heavily depended on for sharecropping agricultural labor. There was failure to fund experiment stations and other research (Kujovich, 1993-1994). Reportedly, from 1896-1915, George Washington Carver served as an instructor and operated an experiment station for agricultural research that was staffed by African Americans (History.com, 2009).

Between the mid-1930s and early 1950s, black historians like Dr. Horace Mann Bond were becoming critical of how HBCUs were so focused industrial trade manual labor workforce development (Butchart, 1988). Research began to increase in the HBCUs in the 1930s. For example, in 1930 Spelman opened the first black nursery school in the nation to train college students serve as a research institute for the study of child care, psychology, and home economics (Range, 1951). There was widespread repressiveness of black Americans, especially in the south, with respect to education and income leading up to the Civil Rights Act of 1964 (Peeps, 1981).

The deficient HBCU progress in research, innovation and tech transfer may be due to their heavy reliance on philanthropy. At the onset, the northern white philanthropists exerted quite a bit of control and influence over the HBCUs and served on their board of trustees (Peeps, 1981). Since views of white racial and ethnic superiority were expressed by northern capitalists who supported and who may have been genuinely concerned about southern blacks, there is some evidence that they contributed to the vocational trade training focus away from funding and advocating scholarly research (Peeps, 1981).

In 1989, a report called *Changing America* predicted a shortfall of scientists and engineers by the year 2000 (Harris, 1992). Pursuant to the findings of the task force on women, minorities, and the handicapped in science, engineering and technology initiated by Public Law 99-383, and a HBCU/ MSI US Department of Defense (DOD) research contract award goal mandated by Public Law 99-661, DoD agencies were directed to review their activities involving HBCUs and MSIs because it was believed that these universities could meet the shortfall with the use of minority

scientists and engineers (Harris, 1992; "National Defense Authorization Act for Fiscal Year 1987," 1986; "National Science Foundation Authorization Act for Fiscal Year 1987," 1986).

In 1991, the DoD funded a project to create a customized blueprint of strategic methods to enhance 30 HBCU/MSIs DOD-related research and development (R&D) infrastructure (Tractell, 1991). The researchers found:

1. Few incentives for faculty to pursue R&D opportunities in part due to the absence of HBCU/MSI R&D program development goals;
2. Little or no grants and contracts infrastructure;
3. No capability assessments of research faculty expertise or facilities (and thus, no marketing of the same);
4. No information technology link tech data and bid opportunity information; and
5. These schools "completely overlooked technology transfer as a business opportunity and as an expected result of the funded activity" (Tractell, 1991).

Between 1991-1992, the US Air Force invested in a HBCU research capability and research facilities database system (Johnson, 1992). In addition, in 1992, the Army Science Board funded an initiative to improve the participation of HBCUs and MSIs which included contracting 5% of their R&D with these higher education institutions (Harris, 1992). Site visits were made to the schools to find research areas that matched the Army's needs. It was reported that "emerging opportunity institutions" that focused on teaching and nurturing undergraduates had the potential to support R&D (Harris, 1992). The HBCUs included in this list were Fisk University, Spelman College, Morehouse College and Tennessee State University. However, their faculty were not aware of federal government contracting processes and emerging technologies research needs. There was a clear need to forge serious, intense and consistent dialogue and a formal research partnership between the Army and the HBCUs/MSIs (Harris, 1992).

Between 1994-1996, the US Air Force funded a study about how the Air Force could best provide technical assistance to Minority Servicing Institutions (MSIs) and HBCUs (Sullivan, 1996). The study included 15 MSIs and 25 HBCUs. Thirty-four (34) had Offices of Sponsored Research. The barriers that the study participants listed included:

1. Having limited resources;
2. Heavy teaching loads;
3. Small or no sponsored research program offices;
4. Ineffective research infrastructure (lab facilities and equipment);
5. Inefficient know-how on research funding opportunities; and
6. Inefficient know-how about their faculty's matching fund capabilities, and ineffective grant proposal writing skills (Sullivan, 1996).

The US Air Force study included a workshop. At the 1996 workshop, the participated debated whether or not HBCUs and MSIs should just focus on teaching and not engage in research at all (Sullivan, 1996). The resulting sentiment was that such a debate would not help their situation and progress. So, the study participants completed the activities and shared their short-comings with the US Air Force.

Thirteen (13) years later, the same challenges were expressed by a new group of HBCU study participants as part of an emerging research institutions study which was very similar to the 1996 US Air Force study ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009). Descriptive statistics about emerging research institutions (ERIs) is provided in Figure 9. As of the year 2014, nearly all of the HBCUs are ERIs; and only 0.87% of the non-HBCUs are ERIs.

The National Academy of Engineering (NAE) and National Research Council (NRC) conducted a workshop in response to the need to increase the number of American universities that can conduct the type of research that would allow America to remain a global economic leader

("Partnerships for Emerging Research Institutions Report of a Workshop," 2009). The study participants identified the following barriers to competing for research funding:

1. Having limited resources,
2. Heavy teaching loads and limited capacity for release time,
3. Small or no sponsored program offices,
4. Ineffective research infrastructure (lab facilities, equipment, hardware and software),
5. Credibility gap and negative branding due to prejudice and bias from individuals at larger institutions,
6. Lack of an entrepreneurial university culture,
7. Hiring and promotion policies that do not reward tech transfer, and
8. Lack of research awards and salary enhancement for research success ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009).

The issue of whether or not tech transfer was beyond the emerging research institutions' reach was also addressed ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009). The group relied on findings from a National Science Foundation (NSF) study of cases of success stories which argued that these institutions could do it if they:

1. Made the commitment to research;
2. Became selective and concentrated on specific research niches;
3. Hired faculty in the niche expertise areas; and
4. Cultivated industry partnerships (Palmintera, 2007).

The NAE and NRC study group advocates for: (1) a road map that includes metrics to gage progress; (2) larger classes; (3) classes that included research as class projects; (4) research sabbaticals; and (5) funding at least one research grant officer or partnering with a larger research university ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009). In 2013, the same sentiment was expressed in a Ford Foundation funded study which states that

HBCUs need to mount a campaign for resources and invest in their research infrastructure (Clay, 2012).

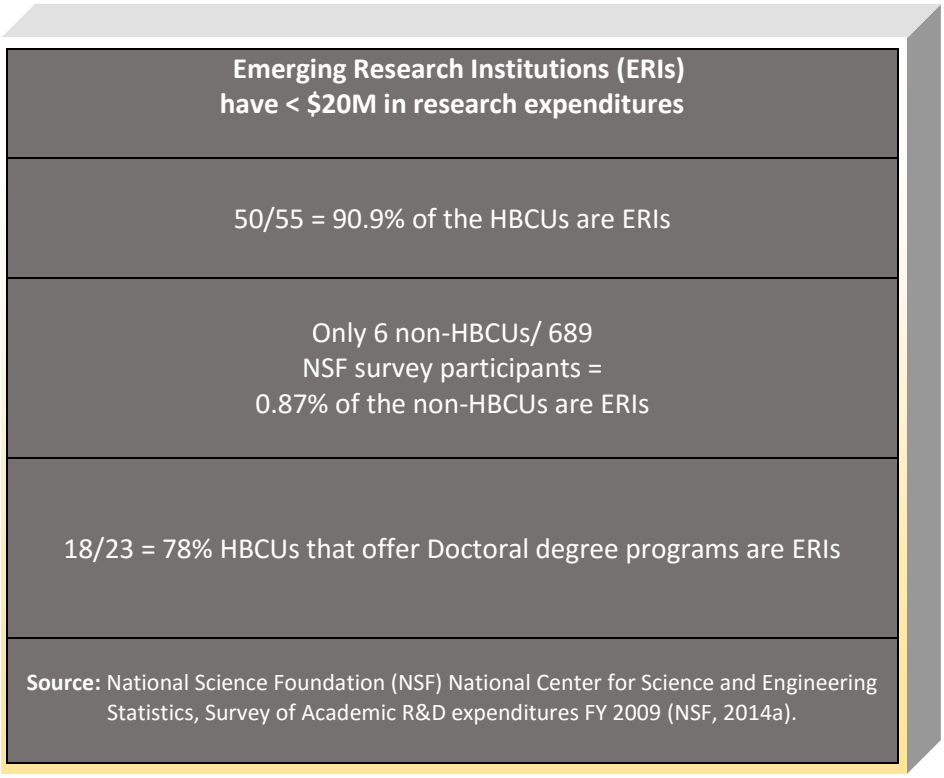


Figure 9. Emerging Research Institutions

In order to increase technology commercialization, sponsored research activities needs to increase. Further, the White House Initiative to strengthen HBCUs has been criticized. For example, the Director of the Office for the Advancement of Public Black Colleges of the National Association of State Universities and Land-Grant Colleges, Dr. Joyce Payne, advocated that (1) the Initiative failed to create an agenda to radically transform the HBCUs and the communities they serve; and (2) has failed "to treat inequality as a deliberate and systematically applied aberration in the distribution

of Federal funds" given that the HBCUs continue to receive significantly less than their non-HBCU counterparts (Juan Williams, 2004).

Of the 908 American colleges that received NSF research funding in FY 2005, only 72 of the funded universities were HBCUs (Toni Coleman, 2010). HBCUs receive less than one (1) percent of America's total R&D funding and each of the top 10 American universities and colleges receives more funding than all of the HBCUs combined. According to the NSF (2011), HBCUs received over $547 million in R&D funding collectively. This represented a 16% increase from 2010 to 2011. The top five (5) HBCUs in R&D expenditures include Morehouse School of Medicine, Howard University, North Carolina A&T State University, Florida A&M University (FAMU), and Jackson State University (John M. Lee Jr., 2013).

Jackson State University is a great example of having leadership that took the university from being a teachers' college to a leading research institution. Dr. John Peoples, the President from 1967-1984 decided to convert Jackson State University to a first-class research institution and aggressively worked to use federal dollars to develop graduate programs. The baton was passed to successors that consistently worked toward this goal. Jackson State University's sponsored research increased from $14 million in 2001 to $56 million by 2006 (Roach, 2007).

In 2005, Claflin University's leadership envisioned increasing their federal government research contracts to support their research agenda (Toni Coleman, 2010). Resources were put into an Office of Sponsored Programs to acquire funding by developing research proposals (Toni Coleman, 2010). Some HBCUs continue to need training in grant writing although federal agencies have been providing training for many, many years.

HBCUs such as Howard University, FAMU, and Jackson State University offer pharmaceutical, agriculture, and engineering degrees programs (John M. Lee Jr., 2013). These schools, as well as

Morgan State, Alabama A&M and Tuskegee University, all have centers for research and innovation. Few HBCUs have technology transfer programs. HBCUs with technology transfer programs include Morehouse Medical, FAMU, Norfolk State, Clark Atlanta University, and Morgan State. There are few HBCUs connected to tech commercialization ecosystems (Bagley, 2013).

Many of the HBCUs want to have more robust technology transfer programs. In fact, the Obama Administration is advocating that they do more. In 2010, the Obama Administration signed Executive Order 13532 entitled "Promoting Excellence, Innovation, and Sustainability at Historically Black Colleges and Universities" (Obama, 2010). This Executive Order established the White House Initiative on HBCUs to be located in the Department of Education:

> "to increase the capacity of HBCUs to provide the highest-quality education to a greater number of students, and to take advantage of these institutions' capabilities in serving the Nation's needs through five core tasks:
> (i) strengthening the capacity of HBCUs to participate in Federal programs;
> (ii) fostering enduring private-sector initiatives and public-private partnerships while promoting specific areas and centers of academic research and programmatic excellence throughout all HBCUs;
> (iii) improving the availability, dissemination, and quality of information concerning HBCUs to inform public policy and practice;
> (iv) sharing administrative and programmatic practices within the HBCU community for the benefit of all; and
> (v) exploring new ways of improving the relationship between the Federal Government and HBCUs" (Obama, 2010).

Johnathan Holifield joined the White House Initiative on HBCUs, the U.S. Department of Commerce's Minority Business Development Agency, and others to develop the concept paper,

"Strengthening the Technology Transfer Capacity of HBCUs" which suggests enhancements to increase the impact of HBCUs on the innovation economy including:

- **Technology Transfer:** HBCUs' technology transfer strategies should emphasize growth of basic, and particularly applied and inter/multidisciplinary, research, which can boost patents, licenses and startup companies.
- **Innovation Ecosystem:** Many HBCUs can become leading facilitators of job-creating, high-growth entrepreneur and enterprise development within regional and state ecosystems (Bagley, 2013).

In 2013, the UNCF took charge of the endeavor to organize the "HBCU Startup and Innovation Initiative" in partnership with the White House Initiative on HBCUs (Lesesne, 2013). This initiative was created to show African American Black students the most important practices within the STEM education, and was used to enable tech-led commercialization at HBCUs. This was in response to President Obama's summons to increase the number of minorities in STEM professions given the lack of HBCU tech commercialization programs. The goal was to train HBCU participants on how to build tech businesses that can excel (Lesesne, 2013). This initiative exposed the HBCU representatives to tech-led entrepreneurship.

Also in 2013, Stanford University's Center for Professional Development and NSF funded National Center for Engineering Pathways to Innovation (Epicenter) hosted a HBCU Innovation Summit with UNCF (Abate, 2013). Participants received an overview of the R&D, commercialization and tech entrepreneurship at HBCUs. The HBCU Innovation Summit participants interested in R&D, commercialization and tech entrepreneurship included the following 17 HBCUs listed along with their Carnegie classifications in Table 1. America's Carnegie Classification of Institutions of Higher Education is a system for classifying universities and colleges. It is used to identify groups of comparable institutions ("The Carnegie Classification of Institutions of Higher Education," 2016).

The classification includes all American accredited, degree granting colleges and universities in the US Department of Education's National Center for Education Statistics Integrated Postsecondary Education Data System (IPEDS) ((NCES), 2015).

Figure 10 shows that the HBCU Summit participants have median scores indicating that they are Masters degree program focused; and their undergraduate programs are balanced arts and sciences/professions. More than half of these HBCUs offer research Doctoral graduate programs.

The Association of Public and Land-grant Universities (APLU) Office for Access and Success has a Commission on Innovation, Competitiveness, and Economic Prosperity (CICEP). In January 2014, the CICEP, the National Collegiate Inventors and Innovators Alliance (NCIIA), the United States Patent and Trademark Office (USPTO) and the UNCF announced the Historically Black Colleges and Universities (HBCU) Innovation and Entrepreneurship Collaborative (or HBCU Collaborative) ("HBCU Innovation and Entrepreneurship Collaborative," 2014; L. Williams, 2014).

The HBCU Collaborative is a cohort of 15 public and private HBCUs:

- Clark Atlanta University
- Fayetteville State University
- Florida A&M University
- Hampton University
- Howard University
- Jackson State University
- Morehouse College
- Morgan State University
- North Carolina Agricultural and Technical State University

Table 1. HBCU Innovation Summit Participants

		2015 Carnegie Classifications		
HBCU	**Student Enrollment**	**Basic**	**Undergrad Instructional**	**Graduate Instructional Program**
Morgan State (public, doctoral/research)	7,698	Doctoral Universities: Moderate Research Activity	Professions plus arts & sciences, some graduate coexistence	Research Doctoral: Professional-dominant
Clark Atlanta (private, doctoral/research)	3,485	Doctoral Universities: Higher Research Activity	Balanced arts & sciences/professions, high graduate coexistence	Research Doctoral: Comprehensive programs, no medical/veterinary school
Dillard (private, Baccalaureate Colleges--Arts & Sciences)	1,200	Baccalaureate Colleges: Arts & Sciences Focus	Arts & sciences plus professions, no graduate coexistence	(Not classified)
Fayetteville State (public, Master's Colleges and Universities /medium programs)	5,899	Master's Colleges & Universities: Medium Programs	Balanced arts & sciences/professions, some graduate coexistence	Research Doctoral: Single program: Education
Florida A&M (public, doctoral/research)	10,241	Doctoral Universities: Higher Research Activity	Professions plus arts & sciences, some graduate coexistence	Research Doctoral: Professional-dominant
Hampton (private, Master's Colleges and Universities /medium programs)	4,393	Master's Colleges & Universities: Medium Programs	Balanced arts & sciences/professions, some graduate coexistence	Research Doctoral: Humanities/social sciences-dominant
Howard (private, Research Universities/high research activity)	10,265	Doctoral Universities: Higher Research Activity	Balanced arts & sciences/professions, some graduate coexistence	Research Doctoral: Comprehensive programs, with medical/veterinary school

Table 1. Continued. HBCU Innovation Summit Participants

		2015 Carnegie Classifications		
HBCU	**Student Enrollment**	**Basic**	**Undergrad Instructional**	**Graduate Instructional Program**
Morehouse College (private, Baccalaureate Colleges--Arts & Sciences)	2,109	Baccalaureate Colleges: Arts & Sciences Focus	Arts & sciences plus professions, no graduate coexistence	(Not classified)
North Carolina A&T (public, doctoral/research)	10,725	Doctoral Universities: Higher Research Activity	Balanced arts & sciences/professions, some graduate coexistence	Research Doctoral: STEM-dominant
North Carolina Central (public, Master's Colleges and Universities /larger programs)	7,687	Master's Colleges & Universities: Larger Programs	Balanced arts & sciences/professions, high graduate coexistence	Post-baccalaureate: Comprehensive programs
Prairie View A&M (public, Master's Colleges and Universities /larger programs)	8,429	Doctoral Universities: Moderate Research Activity	Professions plus arts & sciences, some graduate coexistence	Research Doctoral: Comprehensive programs, no medical/veterinary school
Spelman College (private, Baccalaureate Colleges--Arts & Sciences)	2,135	Baccalaureate Colleges: Arts & Sciences Focus	Arts & sciences focus, no graduate coexistence	(Not classified)
Tougaloo College (private, Baccalaureate Colleges--Arts & Sciences)	900	Baccalaureate Colleges: Arts & Sciences Focus	Arts & sciences focus, no graduate coexistence	(Not classified)

Table 1. Continued. HBCU Innovation Summit Participants

		2015 Carnegie Classifications		
HBCU	**Student Enrollment**	**Basic**	**Undergrad Instructional**	**Graduate Instructional Program**
Tuskegee University (private, Baccalaureate Colleges--Diverse Fields)	3,103	Master's Colleges & Universities: Small Programs	Professions plus arts & sciences, some graduate coexistence	Research Doctoral: STEM-dominant
University of the Virgin Islands (public, Baccalaureate Colleges--Diverse Fields)	2,280	Master's Colleges & Universities: Small Programs	Professions plus arts & sciences, some graduate coexistence	Post-baccalaureate: Comprehensive programs
Xavier University of Louisiana (private, Baccalaureate Colleges--Arts & Sciences)	2,976	Master's Colleges & Universities: Small Programs	Arts & sciences focus, some graduate coexistence	Post-baccalaureate: Other-dominant, with other professional programs

- Prairie View A&M University
- Tuskegee University
- University of Maryland Eastern Shore
- University of the Virgin Islands
- Virginia State University
- Xavier University of Louisiana

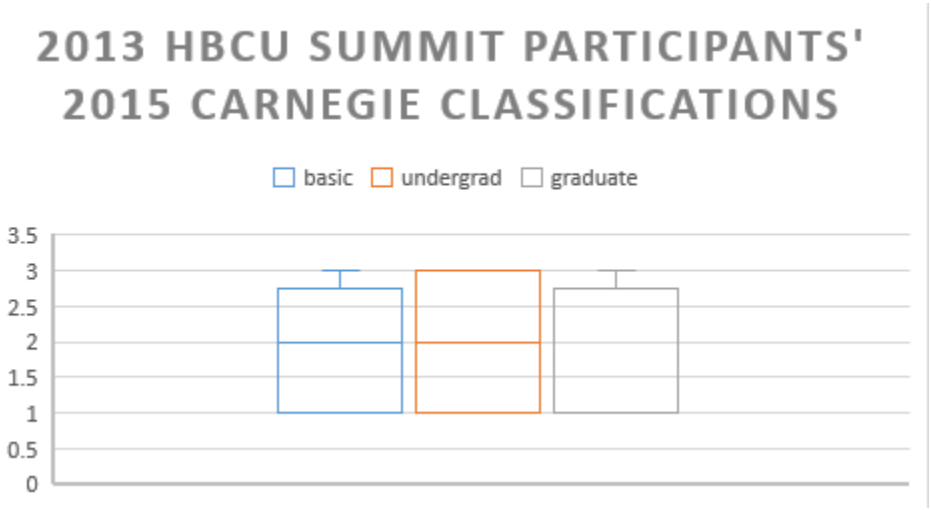


Figure 10. HBCU 2013 Innovation Summit Participants, 2015 Carnegie Classifications

Funded by the Lemelson Foundation, Lumina Foundation and the Monsanto Corporation, the multi-year HBCU Collaborative's goal is to grow entrepreneurship and innovation across knowledge branches in order to build innovation ecosystems. This will likely improve student success by offering new courses, transforming pedagogy and creating relationships with private industry and government partners. Unfortunately, emphasis on course development and the transformation of faculty pedagogy may continue to highlight the imbalance of HBCUs as teaching rather than research institutions. Fortunately, as an extension of the Stanford 2013 Summit, HBCU participants were encouraged to discuss how they can serve as "hubs and nodes of innovation" in STEM entrepreneurship education (Abate, 2013).

With regard to patenting, it has been reported that one of the first HBCU to receive a patent was Shaw University with patent no. 4,083,841 A. From 1969 to 2012, HBCUs received 100 utility-patents. FAMU is active in tech transfer having submitted more than 58 patent applications between 2002 and 2012, and 29 patent issues (John M. Lee Jr., 2013).

There is an annual Association of University Technology Managers (AUTM) patent licensing survey of technology commercialization activity at American research universities. Practically no HBCUs have participated in the survey.

Why are the HBCUs' wheels spinning with lack of traction? This is probably due in part to the high turn-over in HBCU executive leadership caused in part by the lack of financial resources, increasing expectations and increasing pressure to fundraise (Ezzell, 2010; Stewart, 2013). With each new incoming President or Vice President for Research or Development, the HBCU begins from scratch with new initiatives. The problem solutions suggested by the DoD and other studies, get passed over.

In summary, the challenges to HBCU engagement in university technology transfer include:

- Research is backstage to teaching at HBCUs (Nia Imani Cantey, 2013);
- HBCUs need to increase their engagement with federal and state governments and lobby for research funding (John M. Lee Jr., 2013);
- The primary focus on increased fundraising from alum and benefactors (Esters & Strayhorn, 2013) without a commitment to use the funds for technological research and development;
- Need for increased preparedness for managing research funding including improved administrative infrastructures (R. J. R. Charles V. Willie, Ronald Brown, 2006); and
- High-turnover in HBCU leadership which causes instability (Ezzell, 2010; Stewart, 2013).

The HBCU focus is currently still on increasing government funding and donations and many are still tuition dependent. These means for generating funding are vulnerable to downturns in the economy. There is no emphasis on becoming self-sufficient through means like industry funded research or technology transfer. In addition, the challenges that non-HBCUs face when they

engage in university technology transfer will likely be challenges for HBCUs as well. These non-HBCU technology transfer challenges are explored in the Resource Based View section 2.4.1.

2.4 Proposed Theoretical Framework for HBCU Tech Transfer Research

There is currently no known commonly used theoretical foundation noted in technology transfer scholarly research. However, there are at least four (4) relevant theories reviewed in this section. The four relevant theories include: (1) the resource based view, (2) the social comparison theory, (3) the theory of distribution management (aka supply chain management), and (4) paradigm-effect theory.

2.4.1 University Technology Transfer from the Resource Based View

In this section, as illustrated in Figure 11, a review of the scholarship that is related to the resource based view theory used in business strategy is provided.

When applying the Resource Based View, in order to investigate what impacts performance, university technology transfer can be viewed from the perspective of its related human, organizational, and physical resources. In this section, the theory is defined and a literature review of the specific resource inputs is discussed. This is followed by a discussion of the performance outputs in the university tech commercialization process. These performance outcomes include intellectual property licensing and business formation.

The resource based view teaches the importance of firm resource internal endowments on the creation of competitive advantages; and if resources are not imitable (i.e. so good or unique that they are impossible to copy), then they are sources of sustainable competitive advantage (Barney, 1991). This is unlike the resource-dependence theory since the resource-dependency theory links external resource dependencies to performance (Pfeffer, 1978).

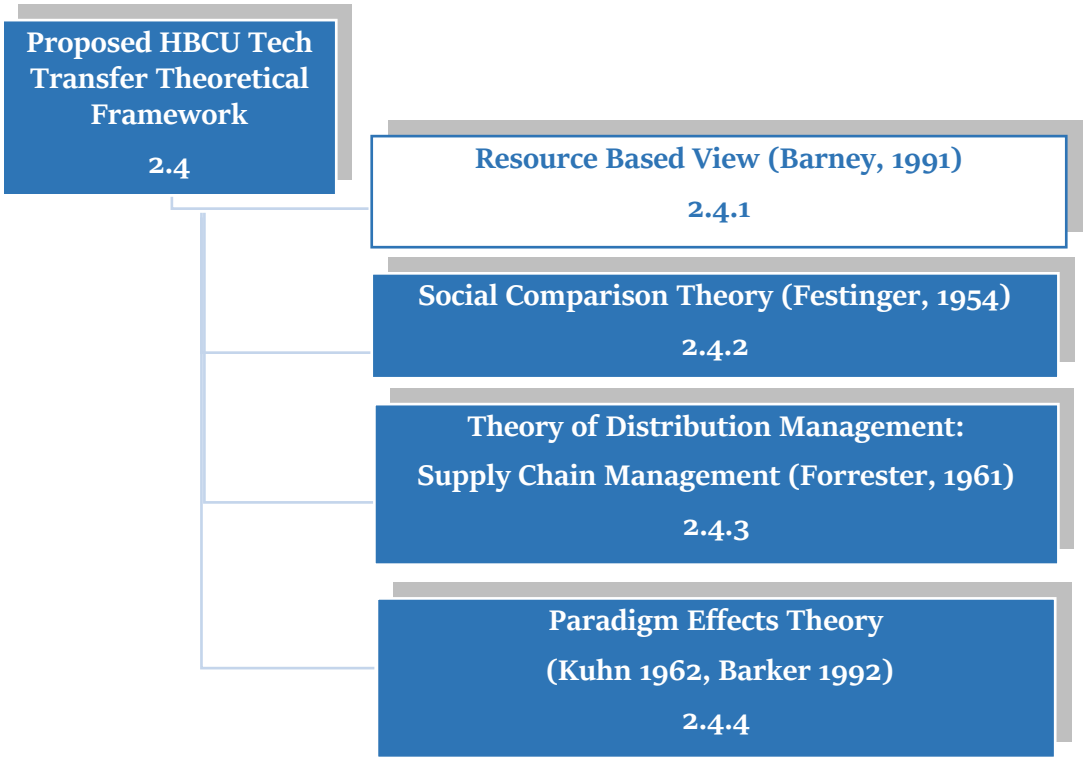


Figure 11. Literature Review Journey: Resource Based View § 2.4.1

The resource-dependency theory suggests that organizations depend on resources; external resources are the basis of power; and an organization's social interactions in an external environment involving these resources can be analyzed to explain the organization's behavior (Pfeffer, 1978). These social interactions tend to improve performance.

The resource based view has been studied in relation to understanding the internal resources involved in creating university spin-offs (Lockett, 2005; Mustar, 2006; J. B. M. Powers, Patricia P. , 2005) in the UK. Further, the resource-dependency theory and resource based view was combined into an integrative theory and applied to the process of how universities commercialize technology (J. B. Powers, 2003). It has also been cited as a possible perspective for the development of system-based strategies for HBCU leadership to use as they embark on a proposed

paradigm shift toward more entrepreneurial based leadership (Andrews, 2016).

This section provides a non-HBCU university technology transfer literature review and serves to increase the understanding of the resources that serve as inputs to the output of licensing revenues. University technology transfer studies of American universities date back to the late 1970s with the inception of the Journal of Technology Transfer in 1978 near the enactment of the 1980 Bayh Dole Act (Society). However, by 2003, few studies investigated factors that explained the differential tech licensing performance between universities (J. B. Powers, 2003). Since that time, these factors have been studied and include faculty reward systems (such as royalty sharing formulas), tenured versus non-tenured faculty researchers, the existence of a medical school, human resource capacity of the TTO, private versus public universities, policies, mission statements, state level economic development activity, number of licensing contracts executed, licensing earnings, land grant universities versus non-land grant universities, existence of science parks, and TTO personnel compensation. Prior research findings and likely gaps in this research area are identified. Please note that this literature review is focused on American universities so as to keep within this study's boundaries.

INPUTS - RESOURCES OF THE UNIVERSITY TECH TRANSFER OFFICE (TTO)

TTO Staffing & Customer Relationships

An ideal TTO has adequately educated and experienced staff. Universities with larger, experienced TTO staff create more contract research and inadequately trained staff is the reason for delayed, slow tech commercialization (D. Wright, 2013). Many staff members have earned MBAs, PhDs and JDs. The TTO staff members are charged with soliciting invention disclosures from faculty researchers, evaluating the invention disclosures, and selecting inventions to patent and license. They typically manage the patent filing and maintenance process. They also market inventions to industries and negotiate licensing deals with well-established corporations, small start-up

businesses, or university spin-off businesses. Licensing to spin-offs and gaining equity in the spun-off firms is a powerful and useful approach to tech commercialization and job creation (E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999).

An inadequate TTO staff slows the tech transfer process down. Slow evaluations, decisions, or negotiations; and incompetent technical advice frustrate faculty researchers and may result in a reduction of invention disclosures and faculty participation in the technology commercialization undertaking. Inside and outside of institutions of higher education, Mowery et al. (2002) states that the management of commercialization at research universities involves a set of skills that is intensely unique. Thus, universities that lack expertise in patenting require considerably more time to improve the value of their patenting (Mowery, 2002).

A 2005 study by Link and Siegel revealed that faculty communicated an incredible amount of frustration with the bureaucracy of universities (Link, 2005). Other problems included a high turn-over of TTO staff and insufficient business experience of the TTO staff in the area of patent marketing (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007). Siegel et al. studied the "environmental and organizational factors" that illustrate differences in university TTOs' production (D. S. Siegel, Waldman, David, Link, Albert 2003a). They used qualitative methods to measure organizational practices that impact TTO productivity. The Siegel research team interviewed 98 research scientists, administrators and entrepreneurs at five (5) universities. They found that TTO staffing, TTO staff compensation, and cultural barricades between industrial organizations and universities impact TTO productivity and performance success. These researchers identified barriers to tech transfer which included conflicting cultures, inflexible bureaucracies, inadequate reward systems, and problematic TTO management (D. S. Siegel, Waldman, David, Link, Albert 2003a).

There may be clashes between intellectual property (IP) attorneys serving as patent counsel outside the universities and the TTO staff which can be problematic (Hertzfeld, 2006). In a survey of IP attorneys, many felt that the TTO staff lacked experience and general business knowledge. The clash of industry's business oriented culture and university scientists leads to partnering difficulties (Samsom, 1993; Zucker, 1996). In addition, while an organization's culture may explain academic entrepreneurship, institutions cannot easily forge university entrepreneurship (Seashore Louis, 1989).

Siegel et al. attributes the tension and inefficiency in university tech transfer to increases in number of and types of research partnerships. They found that the know-how and practices of TTOs are critical factors in the implementation of university tech transfer. Siegel et al. (2003) recommends that TTOs need to address issues, set goals and priorities in order to determine the appropriate resource amounts to invest in: (1) removing cultural and communication barricades that impede the process; (2) developing more flexible technology transfer policies; (3) developing better staffing practices; (4) allocating more resources to TTOs; (5) enhancing rewards; and (6) encouraging improved social relationships and networking opportunities (D. S. Siegel, Waldman, David, Link, Albert 2003a). There needs to be closer interactions between the TTOs, faculty and industry representatives as depicted in Figure 12.

There is evidence that some TTOs are unable to set reasonable goals, communicate and serve faculty researchers effectively, measure the success or failure of their interactions (Van Hoorebeek, 2004). Ill-considered implementation and deficient planning for technology transfer can lead to problems with budget, supply, compliance and task scheduling.

TTO staff can license to well established corporations, small start-ups, or form university spin-off firms to license technology to. The 2004 DeGroof and Roberts research notes that policies related to the high selectivity and high support for spin offs with high growth potential represent an ideal

to achieve rather than an immediate accessible policy since high selectivity and support requires substantial resources (Degroof, 2004; M. B. Wright, Sue; Mosey, Simon 2004). A 2004 study by Markman speculates that high quality TTO staff (e.g. those with scientific backgrounds) may be less concerned with commercialization and may not be motivated by financial needs (Markman, 2004). However, pay to TTO personnel is positively related to entrepreneurial activity; and experienced TTOs are "significantly but negatively related to entrepreneurial activity" (M. B. Wright, Sue; Mosey, Simon 2004).

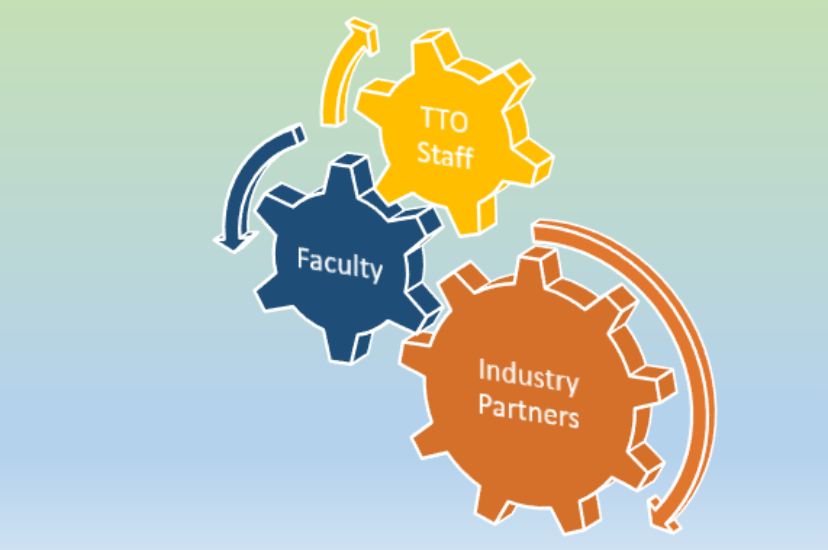


Figure 12. TTO staff, Faculty, and Industry Relationship Building

Research universities increased their engagement in tech transfer with the adoption of the 1980 Bayh Dole Act (E. M. Rogers, 2000). For 35 years, TTO delays and publication delays due to disclosure restrictions have been much debated in scholarly literature and are viewed by some as thwarting open science and maximum knowledge diffusion (Baldini, 2008; R. N. Feldman, Kris, 2008). At the very least, the restrictions frustrate faculty researchers that are anxious to publish their research findings. Part of the debate is the fact that if universities over-patent, they may be

viewed as leaving the non-profit realm and becoming commercial actors that lose their experimental use rights (Kesan, 2009; Van Hoorebeek, 2004). Ivory tower proponents against research universities over-patenting practices and becoming too commercial often advocate for "open collaborations, free participant use agreements, and royalty-free licensing" (Kesan, 2009).

Patent trolls are patent owners that lay low and then take a mature industry by surprise with patent infringement litigation. This is done after industry developers have made irreversible investments and is known as the hold-up or troll problem. Universities' inactivity and delays in commercializing the patents that they own may catapult them into the category of patent trolls as they surface and file patent infringement lawsuits (Lemley, 2007).

It is also important to note that faculty may not submit their invention disclosures and risk violating university policy. They do so in order to avoid the risk of publication delays (Bercovitz, 2003; Cao, 2015). Connections between industry and university work that are mutually supportive would increase invention disclosures. Faculty members decide to disclose based on their perceived patent benefits and what is in it for them (Owen-Smith, 2001). Faculty members that do not disclose inventions created with university resources may get accused of taking university inventions out the back door. Once the word gets out that there are delays caused by the TTO, the word spreads among faculty quickly and this intellectual property leakage has devastating effects on the invention disclosure rates (Tahvanainen, 2008).

Another source of delays is challenges in communication between TTO staff and faculty researchers. Since individuals may come from different scientific disciplines, they may find it hard to communicate about research subjects. A study of the University of New Mexico uncovered this phenomenon (E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999). Each tech specialty has its own scientific jargon and language. Thus,

special effort is required to overcome this problem may cause time delays. This is also a problem between the IP attorneys and engineers (Dahl, 2015).

In the TTOs' defense, the evaluation process can be time-consuming depending on the level and extent of the patent search conducted; and patenting is quite esoteric and complex (Colwell, 2002). Ineffective incentives for research faculty to participate; information irregularities and goals that contradict among the university, faculty inventors, university's TTO and potential licensees, have been called "structural uncertainties". These uncertainties lead to overall tech transfer gray markets, needed expenditures, challenges in the enforcement of inventor restrictions, delays and misaligned reasons and benefits for participation (Kenney, 2009). All of these problematic issues may stifle scientific progress.

Yet, moreover in the TTOs' defense, TTOs are responsible for protecting university owned intellectual property. Here's a related example. In an effort to establish contacts with faculty researchers, GlaxoSmithKline (GSK) established a program to give individual academic researchers access to GSK's pharmaceutical research results and other resources (Osherovich, 2013). The University of California Los Angeles (UCLA) stopped their researchers from participating in the GSK program for fear that the researchers would divulge confidential information that might be covered by prior agreements between the University of California (UC) system and third parties. As required by most research universities, UC requires that researchers disclose any ideas to their TTOs before the researchers share the ideas with outside companies (Osherovich, 2013). The TTO was just doing its job. But, this left the faculty researchers quite frustrated about not being able to participate in such a seemingly great opportunity.

Further in defense of TTOs, they have differential outcomes. In universities, high profile research results enter commercial marketplaces with little problem and with few delays. This results in lucrative licensing income earnings and strong industry relationships (Owen-Smith, 2001).

However, research universities have struggled with commercializing their scientific research results.

Also in the TTOs' defense, tech transfer is challenging for some of the best run private corporations as proven by a research study of a R&D consortium called the Microelectronic and Computer Technology Corporation (MCC) (Gibson, 1991). Gibson et al. concluded that R&D operations need a better way to control technology transfer input variables. In the mid-1980s, IBM simplified their technology transfer program. In their old program, product ideas went to market research, R&D, engineering design, production, sales and marketing. IBM now assembles product development teams that include technology, marketing, and other support staff (Serpa, 1992).

Accumulated Knowledge - Patents

Knowledge accumulation is necessary for patenting and patent licensing. This results in patent licensing revenue generation which is illustrated in Figure 13. Knowledge accumulated in the TTO includes intellectual property (IP) training curriculum and online content that the TTO staff designs and disseminates. It also includes the invention disclosures submitted by faculty researchers, patent applications, and issued patents. In many research studies of the resources provided by TTOs, the amount of inventions disclosed, patents applied for, and patents issued are metrics used to gauge performance success. Much of this information is collected by AUTM in their annual surveys.

Knowledge accumulated by universities in general includes faculty research results such as their stock of educational curriculum, stock of faculty publications, stock of conference presentations, and their stock of patents. Typically, in the past, research studies of the production and performance success of tech transfer offices focused on patents. More recently, arguments have been made to include metrics for training materials, publications, and conference presentations

since industry practitioners rely on these materials for the tech advancement.

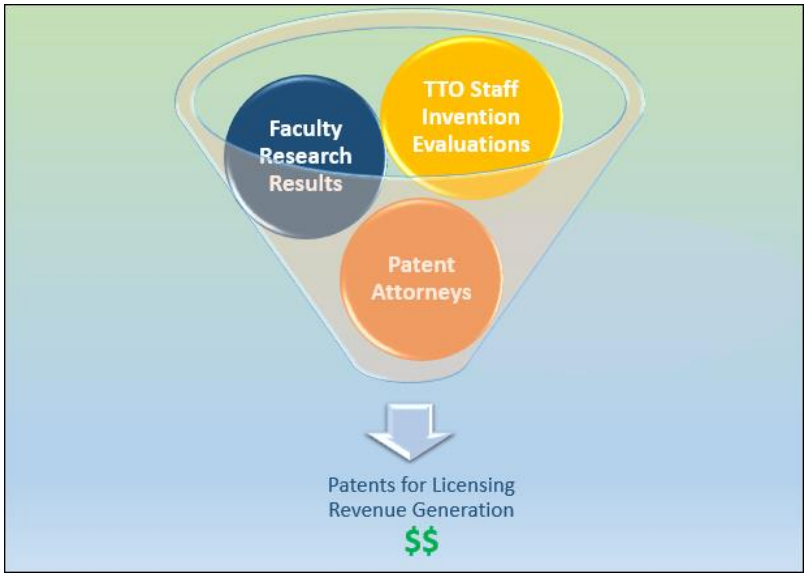


Figure 13. Knowledge Accumulation

TTO IP Protection services

Intellectual property protection services provided by TTOs include training faculty researchers, graduate students, and sponsored research administrators in the university, state and federal intellectual property laws and policies. IP protection is also provided with patent application, copyright application and trademark application filings. The most prevalent is the patent application. Thus, in many research studies of the resources provided by TTOs, the number of patent applications filed is a metric as stated above. Some studies also measure the TTO expenditure on external IP legal counsel. These are typically private patent law firms that assist with patent prosecution. Thus, financial resources to fund legal expenditures are required.

TTO IP Licensing Services

TTOs provide a lot of resources toward maintaining and renegotiating licensing contracts Siegel et al. (2003) cited several environmental and institutional factors that impact productivity noted in prior tech transfer related research studies. University tech transfer productivity is typically measured by the amount of licensing contracts, and the royalty earnings generated by licenses. This research team discovered that personal relationships throughout the university technology transfer process were emphasized more than contractual relationships; and the creation of collective social networking systems could be important (D. S. Siegel, Waldman, David, Link, Albert 2003a). Further, this research team concluded that more external and internal environmental factors should be included in future studies.

Markman et al. interviewed 128 TTO directors to study which TTO organizational frameworks and licensing strategies promote the formation of new ventures. They also studied how the various TTOs' organizational frameworks and licensing strategies relate to one another. They concluded that: (1) equity licensing relates positively to the formation of new deals; (2) obtaining sponsored research via patent licensing is negatively related to the creation of new deals; and (3) in the least, cash licensing is related to the formation of new deals (G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005).

Note that when comparing schools with their peers, those that lag behind make better use of equity licensing and take ownership in their university's spin-off businesses (M. F. Feldman, Irwin; Bercovitz, Janet; Burton, Richard, 2002). With respect to licensing for cash, TTOs license for cash due to their desire to optimize cash flows and reduce risks that are financial and legal in nature. So, licensing for cash is a decision that does not support the creation of new ventures using equity licensing (G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005). With regard to university based business incubators and licensing to small spin-offs or start-up companies, Markman et al. (2005) found that when research institutions of higher

education are primarily paying attention to generating short-term cash flows, they are less focused on the creation of long-term wealth that can be generated with new business ventures (G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005).

Existence of a medical school

The existence of a medical school and biomedical inventions has been cited among several environmental and institutional factors that positively impact university tech transfer productivity (D. S. Siegel, Waldman, David, Link, Albert 2003a). The reason that the existence of a medical school is recognized as helping university technology transfer offices to be successful, is that the licensing royalties on pharmaceutical and other biomedical inventions are hefty. However, the venture capital required to commercialize these technologies is higher than for other industries such as software. Also, in order to keep abreast of cutting edge research, biomedical corporations desired to work closely with and sponsor faculty medical researchers (D. S. Siegel, Waldman, David, Link, Albert 2003a).

Interestingly, with respect to universities that have a medical school, Younhee Kim assessed productivity in technology transfer for 90 universities and found that the average output of those universities is only one percent (1%) greater than research universities that do not have a medical school (Kim, 2013). In addition, the Chapple (2005) team found that the existence of a medical school impacts the state or quality of being efficient negatively (Chapple, 2005).

Faculty Quality

Faculty quality based on the National Research Council (NRC) faculty research quality data is significantly related to tech transfer performance (J. B. Powers, 2003). University tech transfer success is largely dependent on faculty quality and the engagement of the more experienced faculty as mentors to others may create a more trusting culture which will enhance tech transfer performance (D. Wright, 2013). Faculty inventors are frequently involved in the marketing stage

of the university tech commercialization process because they can often identify potential licensees among their industry contacts or based on their know-how. In addition, their expertise makes them ideal to serve as business partners or technical advisors in start-ups using their research results (D. S. Siegel, Waldman, David, Link, Albert 2003a).

There is a perception by some faculty that faculty involvement with the TTOs in university tech commercialization might harm their careers. Link et al. (2007) used the Research Value Mapping Program Survey of Academic Researchers assembled under the Research Value Mapping Program at Georgia Tech and collected a sample of data related to university researchers that hold PhDs at the 150 Carnegie Extensive Doctoral Research Universities between the Spring of 2004 and Spring 2005. It was discovered that it is more likely for tenured faculty inventors to participate in university tech commercialization than faculty inventors that do not have tenure. Link et al. (2007) suspects that industry representatives might be more interested in working with faculty inventors that have more successful research programs. Two additional interpretations for the lack of non-tenured faculty include that technologies might be "going out the back door" and universities are not realizing adequate earnings from their patent portfolios; and/or university reward programs such as royalty sharing need be more aligned with keeping tenured faculty members involved in university tech commercialization tasks (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007).

Friedman et al. (2003) concluded that the continued involvement of the faculty inventor is required for successful technology commercialization programs in research universities. Active faculty inventor engagement is related to the level of royalty revenues received by the faculty inventor. However, the level and extent of inventor involvement does not seem to have been tested in this study. With elasticity of one (1), Friedman et al. (2003) stated that invention disclosure quality is influenced by faculty quality. Increasing faculty quality will result in a return that is one to one (1-1) return on the invention disclosure amount. This will foster an increase in

the amount of licensing deals from university TTOs. Additional measures which should be studied in the future include measures of tech transfer support infrastructure such as incubators, methods of funding the TTO, the organizational framework of TTOs, and the experience of the TTO leadership (Friedman, 2003).

There was an eight-fold increase in university technology licensing from 1980 to 2002 (Mowery, 2002). This was due to an increase in start-up and small tech intensive business formations and the growth of venture capital backed tech firms founded by university students and faculty. Important variables for measuring university tech transfer and entrepreneurship include the: (1) impact of university public research on manufacturing R&D based on the publications and conferences leading to knowledge flow; (2) connection between research universities, other public research organizations, and non-public biotech firms; (3) use of patents and publications by private sector organizations; and (4) whether patents and executed licensing agreements aid university technology commercialization. Financial incentives do not motivate faculty researchers to conduct research that result in the creation of the type of inventions that industry would pay attention to (Colyvas, 2002).

Contrary to the Colynas et al.'s findings, Link et al. researched university tech transfer, joint publications between faculty and industry scientists, and industrial consulting (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007). The Link team cited Siegel et al.'s 2003 and 2004 interviews of over 100 academic scientists. It was discovered that many academic inventors perceive that rewards are not sufficient to justify substantial faculty engagement in university technology transfer (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007). In particular, university royalty sharing formulas were important. They found that faculty reward systems impact TTO productivity and performance success (D. S. Siegel, Waldman, David, Link, Albert 2003a).
With respect to TTO missions, universities that have several goals for technology transfer license production will not produce as much successful tech commercialization output as universities with

clearer focus (Friedman, 2003). With regard to royalty distributions given to faculty as reward and motivator to engage in university technology commercialization, this study found that higher rewards to inventors result in greater technology commercialization outcomes (Friedman, 2003). Further, when royalty income is distributed throughout the campus in general funds for generalized purposes on campus, this practice lowers the royalty earnings available to the faculty inventors. This has a negative effect on TTO performance (Friedman, 2003).

Having a climate that supports entrepreneurship is statistically significant and has a positive impact on all outcomes from the university technology commercialization process (Friedman, 2003). Wright et al. studied different classifications of research university spin-out companies, how the spin-out firms developed internal and exterior resources, university tech transfer policies, and policies pertaining to faculty engagement in entrepreneurial activities, and processes pertaining to faculty engagement in entrepreneurial activities (M. B. Wright, Sue; Mosey, Simon 2004). They contend that paying more attention to the entrepreneurial aspect of university tech commercialization, which involves licensing patents to university spinoffs, is the key. Once an invention is disclosed, evaluated and protected, it may be licensed to a commercial company. Wright et al. (2004) explains that the faculty inventor may continue with related research while having a consulting arrangement with the commercial licensee (M. B. Wright, Sue; Mosey, Simon 2004). Yet, the TTO and faculty scientist may agree that a spinout company is a viable option for tech commercialization. An equity licensing deal and university expenditure in the spinout firm may get negotiated.

The 1989 study by Seashore Louis et al. which concluded that the effect of policies on individual behavior depends on whether the policies are fortified by the behavior (Seashore Louis, 1989; M. B. Wright, Sue; Mosey, Simon 2004). The 1993 study by Samsom and Gurdon argued for clearly expressed rules or principles for conducting university business related to entrepreneurial aspirations (Samsom, 1993; M. B. Wright, Sue; Mosey, Simon 2004).

Other Resources

Other resources are noted in Appendix C. These resources include:

- TTO age;
- Type of university (private, public, land grant);
- Existence of an incubator and/or science park;
- Business expertise, training and technical assistance;
- Resources of the local, regional and state governments;
- Corporate sponsored small business development programs; and the
- Availability of venture capital.

In summary, research universities need methods to fund the TTO inputs (Friedman, 2003). They must also find ways to fund quality research faculty, TTO staff, faculty incentives, and patenting in order to succeed in tech transfer.

OUTPUTS – IP LICENSING & BUSINESS FORMATION

In university technology transfer, patents are marketed to industry representatives with the goal of securing IP licensing agreements as shown in Figure 14.



Figure 14. IP Licensing

Outputs include licensing agreements to spin off businesses and well established corporations. Licensing royalties are typically shared by universities with faculty inventors as a financial reward to the faculty researcher. Outputs also include the number of university spin offs created. The creation of new businesses yields job creation. In 2003, Wright identified primary factors impacting the promotion of spin off activities as incentives, rewards, level of marketing, technical skills of TTO staff, negotiating skills of TTO staff, IP due diligence processes of the TTOs, and internal processes for conducting business development (M. B. Wright, Sue; Mosey, Simon 2004).

The license agreements yield up front and ongoing licensing revenues. The licensing revenues are used to continue and grow the technology transfer activities. In some cases, the licensing revenues are used to increase the R&D activities of the university in general. This may include R&D administrative costs and the cost to improve R&D infrastructure.

With respect to licensing, technology differences impact growth strategies. For example, it may be easier to license software, electronics and biotech. Software ventures typically require less venture capital than biotech or pharmaceuticals (M. B. Wright, Sue; Mosey, Simon 2004). Further, O' Shea et al. studied university spin-off companies (O'Shea, 2005).. They used the

AUTM survey of 141 US research universities. Their input data was obtained from the NSF, National Research Council (NRC), The Center Research Institute for University Performance rankings of top research universities, US Patent and Trademark Office (USPTO), and a survey of university TTO directors.

In O' Shea et al. (2005), it was hypothesized that being successful at creating university spinoffs increases at research universities: (1) that already have a history of success at doing this; (2) with the science and engineering departments at research universities have high quality ratings; (3) a large amount of postdoctoral research staff and faculty working; (4) the more the university's research is funded by private industry sponsors; (5) the greater the university's research budget is in their science and engineering departments (6) the greater the computer science, engineering and life science related federally funded research budgets; (7) the greater the full time TTO staff; and (8) having an university based incubator (O'Shea, 2005). Empirically, O'Shea et al. (2005) concluded that increasing any of the following variables will likely increase the amount of university spinoff companies: (1) university past history of university tech transfer success; (2) a high NRC rating of the research faculty's quality; (3) a high amount of life science, chemistry, IT and engineering research funding; (4) and a high percentage of funding from industry (O'Shea, 2005).

However, with regard to being selective about targeting research funding efforts and patenting investments, it is recommended that a high degree of selectivity can be problematic (J. B. M. Powers, Patricia P. , 2005). When universities are less selective, they provide stronger entrepreneurial supportive oriented universities in a broad sense.

Scott Shane reviewed government reports, white papers, and articles to summarize four (4) aspects of the collaborations between research universities and firms: (1) research sponsored by industry, (2) the development and commercialization of technology, (3) tech licensing for royalty

earnings, and (4) consultative advising (S. Shane, 2002). Shane (2002) found that tech licensing by entrepreneurial companies is affected by the interdependence of available ways to finance tech commercialization. While large firms may be able to fund tech development, small entrepreneurial businesses may struggle to get access to financing. In particular, biotech is extremely capital intensive. Similar to the UK Challenge Fund, there are US research universities that have established in-house programs that help fund the development of technology (S. Shane, 2002).

Further, some universities lower royalties and take equity interests instead of cash royalty payments to help make entrepreneurial ventures more affordable (S. Shane, 2002). Successful technology licensing depends on the expertise of the TTO staff. If spinning off companies is an objective of a research university, then the TTOs need staff that have expertise in forming businesses such as business planning, fund raising, and marketing (S. Shane, 2002). Scott Shane concludes that universities need to change their mindset and philosophy on how they interact with entrepreneurial firms; and have different policies than those used to interact with large, established firms (S. Shane, 2002).

All of these resource inputs and outputs provide the framework for viewing university tech transfer as a supply chain network. This is a novel perspective. Thus, the next Section 2.6 discusses university tech transfer from this lens.

2.4.2 Social Comparison Theory

In this section, as illustrated in Figure 15, a literature review of the social comparison theory is provided.

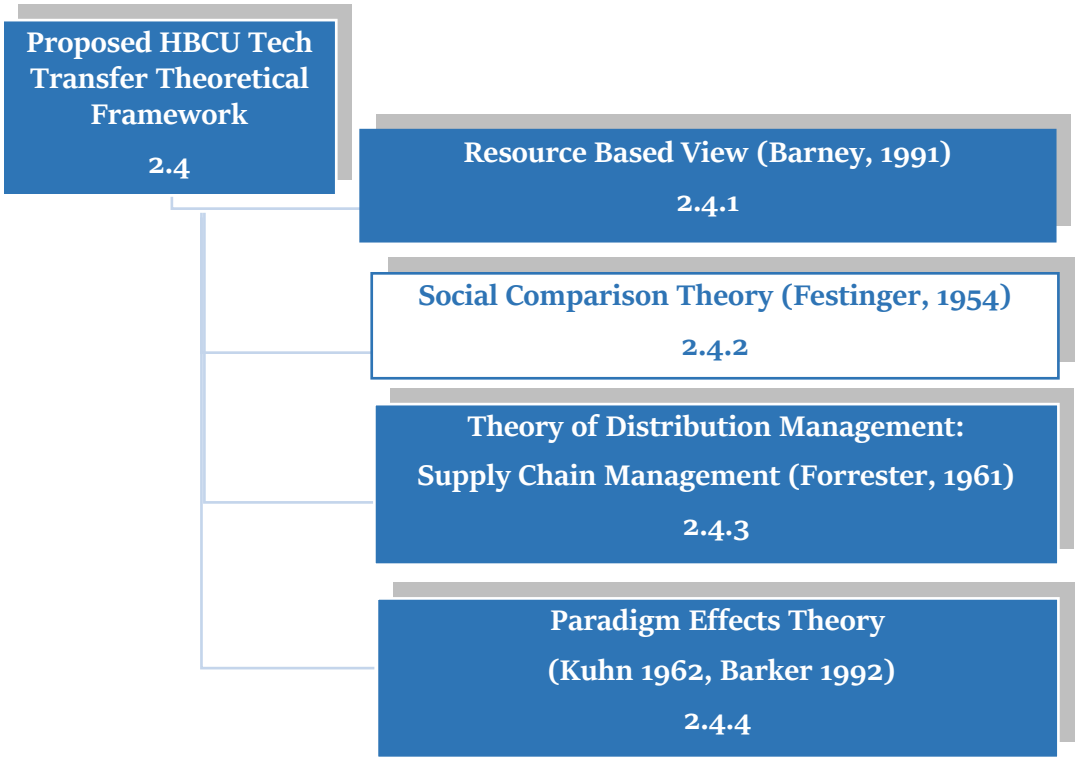


Figure 15. Literature Review Journey: Social Comparison Theory § 2.4.2

As per the social comparison theory (Festinger, 1954), individuals satisfy their fundamental need for accurate certainty and cognitive limpidness by finding information about the accurate certainty of their opinions and the accuracy of their abilities by sizing themselves up to others (Jerry Suls, 2000). HBCUs can learn technology transfer from non-HBCUs. They can compare themselves to the non-HBCUs and improve.

According to Leon Festinger, the need for comparisons to similar others leads to affiliation, pressure toward uniformity in groups, and a unidirectional drive upward that leads to competition. Upward comparisons are with individuals or groups that are believed to be better, and downward comparisons are with those that are believed to be worse off (Abraham P. Buunk, 2007). If a group believes that their own abilities and efforts do not measure up, they may be

motivated to make improvements. The degree that positive or negative perceptions are developed in individuals and groups, is likely to depend on the comparison direction (i.e. upward, downward or horizontal) (Kari Jeanne Visconti, 2013). The upward preference is most common and depends on factors such as whether the motive of self-improvement is more salient (Abraham P. Buunk, 2007). Both upward and downward upward and downward directional social comparisons have a distinctive impact on employee attitudes and behavior (Douglas J. Brown, 2007).

With respect to the social comparison of ability, individuals compare themselves to others that have similar abilities (Festinger, 1954) mainly because this allows them to reduce uncertainty; and enhance or preserve their self-esteem. These comparisons are based on others who are physically present since these people are likely to be similar in key ways (Jerald Greenberg, 2007; Jerry Suls, 2000). This is why physical geographic location matters.

Social comparisons can be biased because individuals see themselves in a positive light that is unrealistic. This bias is called a better than average (BTA) effect. Specific, objectively measured attributes reduce bias in social comparisons (D. Dunning, 1999; D. M. Dunning, Judith A.; Holzberg, Amy D. , 1989). Specific, public, objectively measured attributes show weak or little BTA effect (Allison, 1989; Van Lange, 1991). For example, a HBCU representative would be more likely to state that their performance is above average on subjective and unclear attributes such as idealism than on more specific attributes such as licensing revenues generated. Thus, any tool kit that is developed for HBCUs to compare themselves to should be specific with objectively measurable attributes. Note that the bias effect may be exaggerated and individuals believe that they are less likely than average to reveal rare, unusual abilities and more likely to display ability that is common (Moore, 2007).

Perceptions of Victimization and Threats

Much of the literature review about HBCU financial burdens depicts HBCUs as victims of social inequality. Visconti et al. studied 192 children ages 9-10 and their being picked on by peers (Kari Jeanne Visconti, 2013). Visconti et al. advocate the use of the social comparison theory system for researching the affiliations between children's propensity to assign or attribute victimization by persons of the same age or social group and peer harassment causes, and subsequent psycho-emotional adjustment to feelings of loneliness and peer unacceptance. The innate tendency for humans to compare themselves with others influence how humans evaluate themselves (Kari Jeanne Visconti, 2013). While, HBCU representatives are not minor children, the peer victimization and social adjustment phenomena are relevant here.

With respect to the social comparison direction, attributing victimization or peer harassment to highly valued or positive self-characteristics that may bring about peer jealousy would likely be suggestive of downward comparisons (Kari Jeanne Visconti, 2013). Downward comparisons are also called superiority beliefs associated with having more self-esteem. This may be the case with many HBCU representatives who view their HBCU employer with great high esteem and with great pride. However, attributing victimization to undesirable or unvalued characteristics suggests upward social comparisons. These are inferiority beliefs that contribute to perceptions among peers that the victims have a lower social position or place of prominence. This viewpoint is also prevalent in the literature about HBCUs. Negative emotions and lower self-esteem are linked to upward comparisons are linked with among the individuals making the comparison (Kari Jeanne Visconti, 2013).

Horizontal comparisons mirror perceptions that one is neither inferior or superior. For example, if an individual makes a horizontal social comparison, the person may believe that the harassment or victimization is due to mutual enmity or a mutually antipathetic peer relationship. In other words, the two groups or individuals being compared “may have a history of not liking one

another, provoking each other, or being caught up in a bully–victim relationship" from which the victim perceives he, she or it cannot escape (Kari Jeanne Visconti, 2013).

With respect to locust of control social equality perceptions may make children feel personal control in the victimizing situation and shield children from substandard social adjustment (Kari Jeanne Visconti, 2013). However, one's own beliefs toward the person that intimidates and hurts him (i.e. taking the stance "I don't like him either!", may mirror a state of affairs beyond their control, and may be especially damaging to the one who is experiencing the victimization (Kari Jeanne Visconti, 2013). This train of thought is particularly relevant to the plight of HBCUs given the very public debates over whether HBCUs should continue to exist and receive funding (Gasman, 2006; Gloster, 1967; Jencks, 1967). If the HBCU leaders take this stance and attribute their financial situation in this manner, it can prove to be detrimental to the HBCUs.

Social comparisons provide an ideal theoretical framework for researching the financial plight of HBCUs because according to social comparison theory, threatening conditions motivate people to compare themselves to others who are facing a similar threat (Melissa Legg, 2011). Thus, HBCUs would more likely benefit from comparing themselves to non-HBCUs that are smaller research institutions rather than larger research institutions with more robust and advanced tech transfer programs as illustrated in Figure 16.

When individuals ask themselves if they can perform a task, they compare themselves to other people who already are performing that job (Jerald Greenberg, 2007). This comparison occurs if the proxy surrogate's performance on the initial job is perceived to be similar to the comparer's performance and (2) if the surrogate is believed to have put in a lot of effort on the initial job. If the comparer does not see similarities, the comparer may reject skills training or diagnostic information about performance. This is important to note when moving forward with a useful tool kit for HBCUs to use.



Figure 16. Social Comparison Theory Illustration
Source: Nimita Shah, Psychologist (Shah, 2014)

Besides rejection of training and diagnostic information, individuals or groups may deflect problems in order to preserve their self-images or self-identities (Jerald Greenberg, 2007). Since upward comparisons may be threatening to some people, deflection is most likely to occur. Deflection tactics include undermining, lowering assessment values, redefining comparisons as non-diagnostic and highlighting differences between the comparer and the group the comparer is compared to (Jerald Greenberg, 2007).

Other related theories

ATTENTION BASED VIEW

The attention based view teaches that human attention is limited and organizations are limited in what they pay attention to (Cyert & March, 1963; Ocasio, 1997). It is argued herein that universities may struggle with increasing their licensing revenues because they are not paying sufficient attention to licensing. Awareness of the problem is the first step in resolving it. This author has proposed that university technology transfer office staff pay more attention to

intellectual property protection than patent marketing or licensing and this result in lower licensing revenues and lower overall performance (C. Hamilton, 2015). It is also propositioned that technology transfer offices with less experienced staff pay more attention to intellectual property protection than patent marketing and licensing (C. Hamilton, 2015).

MINDFULNESS THEORY

Mindless behavior is comprised of relying on categories or differences pulled from the past related to rules and routines that govern our behavior (Barker, 1992; Langer, 2000). Mindfulness is the method of pulling and drawing out new differences drawn in the present that can lead to a "(1) a greater sensitivity to one's environment, (2) more openness to new information, (3) the creation of new categories for structuring perception, and (4) enhanced awareness of multiple perspectives in problem solving." Mindfulness is a deeper, magnified state of awareness and engagement known as "being in the present". With respect to inequality that HBCUs may perceive to have faced or currently face, mindfulness theory has been used to constructively reinterpret many varying societal problems, such as the promulgation of stereotypes and prejudices. The mindfulness theory teaches that "mindlessness can show up as the direct cause of human error in complex situations, of prejudice and stereotyping" (Langer, 2000).

2.4.3 Theory of Distribution Management

In this section, as illustrated in Figure 17, a literature review of the theory of distribution management is provided. The Theory of Distribution Management is a business management theory that because institutions are so interlaced, system dynamics influences the function of product R&D, promotion and sales (Mentzer, 2001). In 1958, Forrester introduced the theory of distribution management by using a computer simulation to describe product order information flow and how this influenced the performance of production and distribution (Mentzer, 2001).

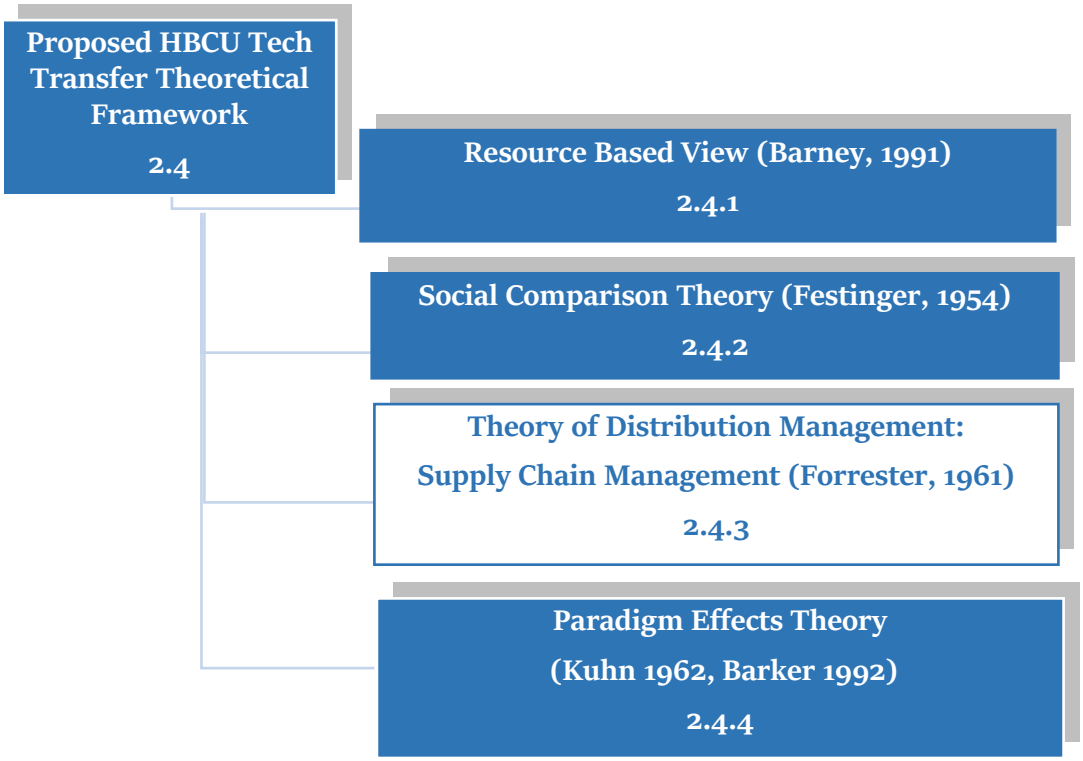


Figure 17. Literature Review Journey: Theory of Distribution Management § 2.4.3

Forrester's theory of distribution management is a system dynamics idea applied to production distribution noted in Forrester's 1961 book *Industrial Dynamics* (Forrester, 1961).

System dynamics is the process of combining the theory, method and philosophy necessary to analyze the behavior of a system in order to provide a common foundation that can be applied whenever it is desired to understand and influence how things change over time (Forrester, 1993). The father of System Dynamics is Dr. Jay Forrester.

In 1958, Forrester introduced a theory of distribution management which is believed to be the first instance of a reference to supply chain management (SCM) (Mentzer, 2001). Forrester's theory of

distribution management was described using a computer simulation of order information flow and how this influenced the performance of production and distribution. This system dynamics idea as applied to production distribution was noted in Forrester's 1961 book *Industrial Dynamics*. The actual acronym SCM was used by Oliver and Webber in 1982 (Corominas, 2013). SCM gained popularity in the 1990s due to global sourcing's emphasis on time and quality competition (Kumar, 2001; Mentzer, 2001). Thirty years later, SCM is still gaining in popularity (Corominas, 2013).

The final customer is part of the supply chain (Mentzer, 2001). Whether or not to include customers in the definition of supply chain has been much debated (Corominas, 2013). From this lens, and for the purposes of this study, industry partnerships and collaborations in the university tech transfer arena would be a part of a university tech transfer supply chain network. This is particularly true since industry sponsored research is driven by end-users decision processes (Dai, 2005).

The players in supply chains are customers who are distributors, wholesalers or retailers. Distributors take inventory in bulk from manufacturers and deliver the inventory to customers. While wholesalers buy from distributors or manufacturers directly, retailers stock products in smaller quantities and sell them to the general public. Supply chain operation models depict functional processes of plan, source, make, deliver and return take place within every stage of the supply chain (Scott, 2011). Supply chains are "networks" of three (3) or more organizations involved in downstream and upstream linkages. The supply chain includes value producing activities and processes. The valuables are products and services delivered to consumers that enhance performance (Ketchen, 2008; Kumar, 2001; Mentzer, 2001). The traditional SCM view is to move goods or services in a tactical manner as a cost center. Yet few organizations track their total supply chain performance (Ketchen, 2008).

Every organization's competitive success depends on how well its entire supply chain is able to compete by delivering value to its customers (Kumar, 2001). Organizations need to be adaptable because, for example, simply minimizing costs may not result in the best value (Ketchen, 2008). Supply chains have to be managed because customers demand more value; and advanced computerized planning systems make it possible to manage supplies in order to meet demands. Advanced planning systems include optimization techniques, forecasting and scenario planning that provide what-if analyses and simulation (Kumar, 2001). Best value supply chains provide alignment in the interests of all participants. This alignment can be achieved through collaborative forecasting with suppliers (i.e. in university tech transfer, suppliers are the TTOs) and customers (i.e. industry licensing partners) (Ketchen, 2008). Best value sales deals are more like teaming agreements and participants are encouraged to take the time to sit together and agree on anticipated business levels (Ketchen, 2008).

SCM can be viewed as a management philosophy that includes viewing the supply chain as a whole systematically; a strategic adaptation to align intra and interfirm operational and strategic capabilities with tactical activities; and a customer clear visual that forges customer value propositions that are new and customized (Mentzer, 2001). With respect to strategy, the goal is to forge an integration of processes to achieve integrated behavior and long term relationships. In best value supply chains, decision makers decide which relationships are best to cultivate based on the value that the relationships bring to the table (Ketchen, 2008). Thus, there is a need for demand and supply planning; sales and operations planning (S&OP); and customer service improvements through S&OP (Scott, 2011).

S&OP can improve customer service if it is used to increase the demand forecast quality which requires consistent transparent and accessible numbers. Second, the S&OP provides improved forecasts which improves the reconciliation of demand and supply and reduces forecast bias. Third, the S&OP provides improved reconciliation of demand and supply which leads to improved

customer service since what results is a realistic supply plan. The six (6) guiding principles of S&OP implementation include: (1) engaged and educated stakeholders who understand the whole process; (2) one set of numbers which align production, sales and marketing; (3) accountability and decision making; (4) an alignment of business objectives; (5) an appropriate time horizon and (6) understanding the benefit of the S&OP (Scott, 2011).

Very little seems to have been written about tech transfer as a supply chain network. However, product development is recognized as a fundamental link in the technology supply chain (Tatikonda, 2003). Further, it has been proposed that product tech transfer effectiveness is greatest when companies delicately match the technology types that they want to transfer with their industrial supplier relationships in inter-organizational interactions (Tatikonda, 2003).

If tech transfer is viewed from this supply chain lens, the demand for invention disclosure evaluations related to supply chain processes such as the demand forecast methods and demand arrival processes that are dedicated internal resources. In this context, HBCU tech managers are supply chain managers aiming for efficiency to maximize licensing revenues. Typical supply chain nodes can be compared to tech transfer players and items that carry out various processes and activities to impact licensing revenues as noted in Table 2.

TTOs are impacted by inventory reduction and fill rates, customers' satisfaction, revenue loss; and the costs for inventory, managing resources are the most significant tasks of a capable supply chain manager. University tech transfer supply chains are complex network systems. Modelling and simulation can be used to investigate, find optimal solutions, and predict outputs in such complex networks.

It is novel to view the technology transfer process as a supply chain. In tech transfer, a network node is a TTO distribution center (TDC), lab, or TTO store. The supply chain can begin with one

or more labs and end with one or more TTO stores. The TDC's satisfy TTO stores' and demands from the marketplace.

Table 2. University Tech Transfer Supply Chain Network

Typical Supply Chain	University Tech Transfer
Suppliers	Tech transfer specialists that evaluate inventions
Manufacturers Plants	Faculty inventors Research labs
Distribution Centers (DCs) Stores	Tech transfer offices (TTOs) TTO Distribution Centers (TDCs)
Inventory	Invention disclosures Patent applications Patents
Inventory costs	Legal fees
Customers	Faculty inventors Industry partners

The same process can be established for TTOs. However, in tech transfer, the sales and store demands are much lower. While in traditional supply chains, in order to protect against defects, unstable production, supply and demand imbalances, and uncertainties, inventory is held (Scott, 2011). This tight inventory control is not the goal in university technology transfer. But, minimizing the time to evaluate invention disclosures, minimizing costs, and maximizing licensing revenues are issues for TTOs.

University tech transfer is a process oriented professional industry. Interestingly, there is a need for future research in SCM planning and scheduling in process industries (Amaro, 2008; French, 2006). Few supply chain operation scholarly contributions deal with process industries (Amaro,

2008; M. B.-R. Fleischmann, Jacqueline M.; Dekker, Rommert Dekker; van der Laan, Erwin; van Nunen, Jo; Van Wassenhove, Luk, 1997).

2.4.4 Paradigm-Effect Theory

As depicted in Figure 18, a review of the paradigm-effect theory is provided in this section.

Shifting from a non-research oriented to a research oriented university

As aforementioned, HBCUs are well known as teaching institutions. They are heavily branded as such. Thus, an increase in research and tech transfer activity would be a shift from a non-research orientation to a research orientation. As noted in the *Definition of Key Terms* section of this study, in 1962, physicist Dr. Thomas Kuhn introduced the concept of the 'paradigm shift' as related to certain scientific work. Kuhn taught that certain scientific work provides a resourceful framework of concepts, results, procedures, and traditional practices for which subsequent work is structured and follows. This lasts only for a time and then shifts (Kuhn, 1996). The paradigm-effect theory is that it is difficult to notice the need for the shift when an existing paradigm is very strong. This leads to paradigm paralysis. A related business strategy theory which applies Kuhn's philosophy of science was developed in 1992 by Joel Barker which states that organizational leaders can learn to anticipate the future better rather than fear it by learning strategic exploratory skills that help them notice and manage needed paradigm shifts (Barker, 1992).

In the book entitled *Paradigms*, Joel Barker teaches that organizational leaders can learn to anticipate the future better rather than fear it (Barker, 1992). This is especially true for HBCUs. As outlined in this research study, HBCU leaders have come to rely heavily on government and philanthropic financial assistance. They fear government and philanthropic charitable agency budget cuts. Barker cites Peter Drucker and states that most managers operate in a reactive mode and need to improve their skills in the area of anticipating the future in order to avoid problems and identify opportunities (Barker, 1992). According to Drucker, noteworthy competitive

advantage is the responsibility of leaders who "anticipate well" in stormy times (Barker, 1992). Good anticipation of the future requires good strategic exploration skills (Barker, 1992).

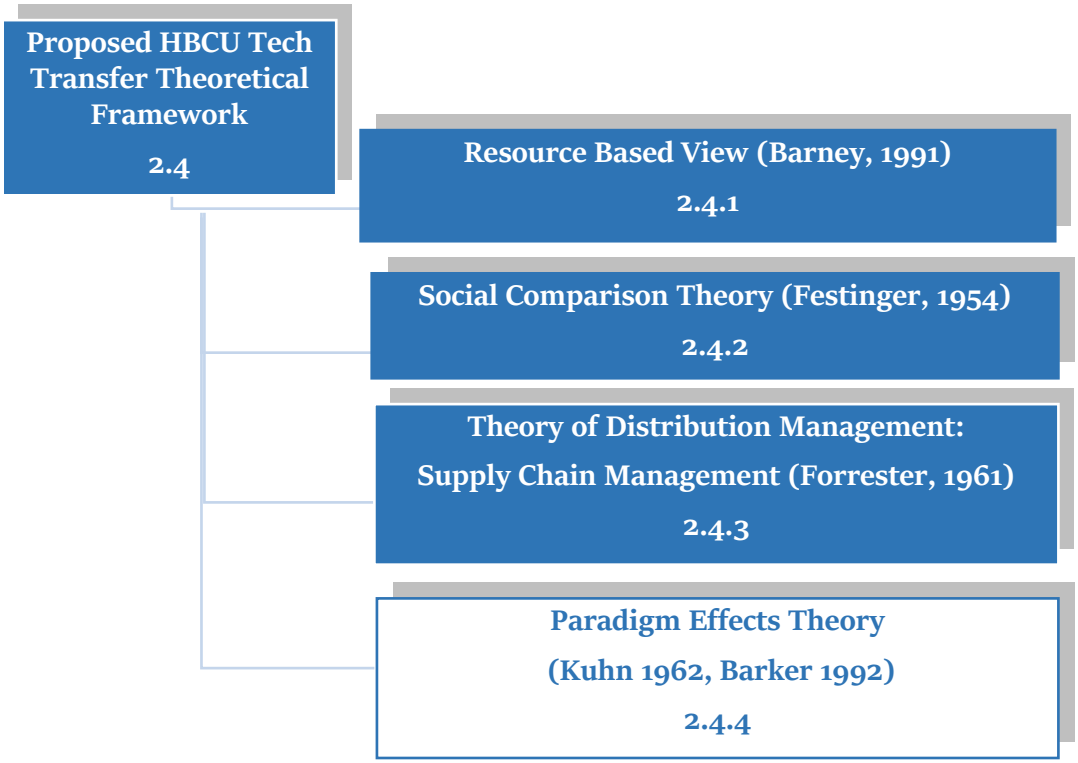


Figure 18. Literature Review Journey: non-HBCU Tech Transfer § 2.4.4

With respect to sequencing, first organizational leaders must be able to understand what influences their perceptions (Barker, 1992). Next, they have to be willing to be open- minded to more than one right solution to their problems and exercise divergent thinking. Then, they are to focus on data integration and prioritize their choices. Finally, they are to exercise mapping and imaging to envision and draw pathways to from their present situation to a better future.

With regard to the HBCUs financial woes, the proposed solution is to create a paradigm shift in which HBCUs become more research focused on technology development and commercialization. The focus of this study is on facilitating the data integration, mapping and imaging phases with the use of a proposed tool kit for university technology transfer. The proposed advanced planning system tool kit is a paradigm. It will serve as set of rules for direction in the technology transfer game that defines boundaries and guides the HBCU leaders in how to conduct themselves inside the boundaries in order to succeed (Barker, 1992). HBCUs paradigm shift will be to change toward playing this new game with a new set of rules (Barker, 1992). There are two (2) reasons that leaders do not solve problems right away. They either lack some technology or tool; or they do not know how and lack sophistication (Barker, 1992). The proposed advanced planning system tool kit will close the gap on this lack of know-how.

With respect to sequence, Barker cites James Bright, a pioneer in technology forecasting, and provides the following 10 step sequence for leaders to think about (Barker, 1992):

"1. The established paradigm begins to be less effective.
2. The affected community senses the situation, begins to lose trust in the old rules.
3. Turbulence grows as trust is reduced.
4. Creators or identifiers of the new paradigm step forward to offer their solutions (many of these solutions may have been around for decades waiting for this chance).
5. Turbulence increases even more as paradigm conflict becomes apparent.
6. Affected community is extremely upset and demands clear solutions.
7. One of the suggested new paradigms demonstrates ability to solve a small set of significant problems that the old paradigm could not.
8. Some of the affected community accepts the new paradigm as an act of faith.

9. With stronger support and funding, the new paradigm will gain momentum.
10. Turbulence will begin to wane as the new paradigm starts solving the problems and the affected community has a new way to deal with the world that seems successful" (Barker, 1992).

In the very beginning, according to Joel Barker, the first three (3) requirements are influence understanding, and a willingness to embark on divergent and convergent thinking. Joel Barker's book Paradigms focused on influence understanding and it points out how (a) individuals' world views are influenced by paradigms; (b) because people excel at using their present paradigms, they resist needed changes; and (c) usually it takes an outsider to create the new paradigm.

Progress is measured by measuring success. According to Joel Barker, success is measured by the ability to solve problems and keeping score of problems solved (Barker, 1992). Thus, given the HBCU financial problems when there are turbulent government and philanthropic budget cuts, success can be measured by their ability to find other financial sources of income. Finding other sources of income will solve their problem.

Paradigm shift movement and barriers

Paradigm shifts may result in a new trend. Explosive, fast moving trends may cause great turbulence (Barker, 1992). In high turbulence, there is pressure by people who expect and demand great change. In the paradigm shift proposed in this research study, it will likely be like most trends and will take time to gather momentum. That time will help reduce negative impacts and will help to optimize opportunities.

The foreseen barriers in the proposed HBCU paradigm shift toward being more research and tech transfer oriented are the various forms of resistance to change. Resistance to change causes

practitioners of prevailing paradigms to hold on their model far past when they should have begun seeking out a new paradigm (Barker, 1992). The HBCU leaders and managers may respond harshly to outsiders. The truth is they work hard at what they are currently doing and have successfully practiced their prevailing paradigm. Thus, they may not believe that they need to change. So, they would have a difficult time listening to outsiders who ask them to change their ways (Barker, 1992).

Further, HBCU leaders and managers have physiological filters that only allow them to sense, see and hear things being pointed out to them through their own existing paradigms (Barker, 1992). So, any data that exists in the real world that does not fit their own old existing paradigms will have a difficult time getting through those physiological filters. Old paradigms such as an HBCU leader or manager believing that HBCUs have been victimized and not treated fairly and equal to non-HBCUs will suffer from the fact that this old paradigm will block their ability to perceive and understand potential solutions to their plight (Barker, 1992). One of the rules of paradigms is that the more invested the HBCU leaders and managers are in one set of rules, the harder it is to see an alternative (Barker, 1992). This leads to complacency and getting stuck in the belief that being victims to inequality is "just the way it is". Energy may be focused on trying to eradicate this inequality rather than doing more to gain more financial self-reliance by finding other sources of income such as increasing research and development funding and technology commercialization income.

Another source of resistance to change is resistance to learning new expertise. This is particularly concerning for the HBCUs that are currently primarily teaching oriented. They are brilliant at teaching. But when the rules change, they may be left feeling vulnerable and even helpless (Barker, 1992). The game changer for HBCUs has been the steady downturn in non-research oriented government funding and charitable donations. The down economy is particularly harsh

on universities without sources of financing such as research and development funding and licensing revenues.

Finally, in the book Paradigms, Joel Barker cites Arthur C. Clarke who wrote in his book *Profiles of the Future* that it is extraordinary how conservative and competent engineers and scientists can fail when they think that what they are investigating is impossible (Barker, 1992). Likewise, some HBCU leaders and managers may believe that it is impossible to succeed in R&D and technology commercialization. This is the worse form of resistance to change.

As noted in the sequenced steps 7-9, it is recommended herein that the paradigm shift proposed in this research can be handled in this manner:

a. The use of the proposed tool kit for HBCU tech transfer should be suggested as a new paradigm to be used as a management tool in a case study by one or more willing HBCUs to demonstrate an ability to solve a few noteworthy problems that the old paradigm could not. They can manage within the tool kit paradigm and lead the shift between their old prevailing paradigm and the new one (Barker, 1992). This would result in a success story.

b. Through promotional marketing both internal to individual HBCUs and via external social media marketing, leaders in HBCUs can be encouraged to accept the new paradigm (i.e. the proposed tool kit) as acts requiring faith.

c. With adequate funding and other stronger support, the new paradigm will gain energy and velocity. It will have momentum. HBCU leaders will need to be encouraged to make investments in their technology transfer infrastructure, staff training, and faculty training.

Paradigm Shifters

According to Joel Barker, paradigm shifters are almost always outsiders (Barker, 1992). Thus, the players in the proposed paradigm shift espoused in this dissertation study could be non-HBCU partners and industry partners. It could very well be HBCU alumni that are working in industrial corporations. Joel Barker teaches that there is power in ignorance and innocence when coupled with human creativity (Barker, 1992). Thus, Barker advocates that young people fresh out of college (which would include HBCU alums) and older people that are shifting fields are ideal paradigm shifters (Barker, 1992).

Paradigm Pioneers

With respect to paradigm pioneers, Joel Barker teaches that they are typically the courageous individuals with heart and intuition that act initially out of faith as mentioned in Step 8 above in the sequencing (Barker, 1992). These individuals will likely be faculty inventors driven by frustration of the old paradigm and they will appeal for a new paradigm. Mavericks and tinkerers such as the faculty inventors are insiders that lead the change (Barker, 1992). Arguably, young people need not necessarily be fresh out of college as Barker teaches, but could be HBCU undergraduate and graduate students that are entrepreneurial and desire to help pioneer the paradigm shift. Other potential internal pioneers are the HBCU leaders and managers.

2.5 Literature Summary and Gaps

In general, there is little or no current research available about HBCUs willingness to engage in university tech transfer. Much of the literature reveals the state of affairs of HBCU finances. HBCUs graduate 60% of America's black engineering students and are becoming increasingly threatened financially. They once were funded at more than 50% by industrial partners which ended with the Great Depression in the 1930s. HBCUs have grown increasingly dependent on government assistance and need new revenue sources. The schools are heavily teaching oriented, lack patents and lack tech transfer operations. In comparison, over the past 25 years, non-HBCUs

have increased their licensing revenues. HBCUs can learn from the non-HBCUs.

With regard to theory, the literature review reveals that since there is currently no theoretical framework for university tech transfer, it follows that there is no theoretical framework for researching HBCUs' technology transfer activities and tool development. In the literature review, university tech transfer was studied from the perspectives of the resource based view. Primary resource inputs include TTO staff size, patents, legal services, marketing services, and the existence of medical schools. Primary outputs include IP licensing revenue and business formation. University tech transfer was also studied from the novel perspective that it is a supply chain network.

The shift of HBCUs toward becoming research and tech transfer oriented will be a paradigm shift. The paradigm shift will likely follow a 10 step sequence which begins with realizing that the current paradigm has become less effective and ending with the waning of turbulence once changes are implemented and supported. To motivate HBCUs toward making this paradigm shift, research related to the social comparison theory is quite revealing. Social comparison theory research discloses that groups are likely to compare themselves to groups of the same ability and in the same physical geographic location.

Despite the struggle, many universities are doing quite well with licensing their technology. Thus, tech commercialization can prove to be a viable financial resource for HBCUs if the HBCUs obtain adequate guidance. The literature review revealed important reasons why faculty and universities may choose "not" to engage in tech transfer. Challenge areas include faculty quality, lack of adequate resources, lack of resource planning and benchmarks, lack of incentives, and time delays. Their problem areas and needs are listed in Table 3 along with tools proposed herein this study that can serve to alleviate problems.

Based on this extensive literature review, Table 4 provides a list of fifteen (15) gaps in the existing research. The select gaps that this dissertation research fills are noted with check marks. This dissertation research will address four (4) these gaps by addressing the lack of involvement of HBCUs in university technology transfer and addressing the use of advanced planning system tools in a supply chain network to resolve this problem.

Table 3. Non-HBCU Technology Transfer Needs

Proposed Tool	Challenge	Reference
Model University IP Policy	Competent TTO Staff: • Educated • Experienced • Skilled in marketing • Skilled in negotiations • Skilled in supporting spin-off businesses • Well compensated	(Mowery, 2002) (S. Shane, 2002) (M. B. Wright, Sue; Mosey, Simon 2004) (D. S. Siegel, Waldman, David, Link, Albert 2003a) (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007) (D. Wright, 2013)
Model University IP Policy	Flexible, non-bureaucratic university culture	(Link, 2005)
Model University IP Policy	Entrepreneurial supportive university culture that: • embraces and licenses to university spin-offs • clearly expresses rules for faculty & student entrepreneurial business engagement	(Friedman, 2003) (M. B. Wright, Sue; Mosey, Simon 2004)
Model University IP Policy	University and TTO works to overcome cultural barricades between industry, TTO staff, faculty, and IP attorneys by: • Increasing social relationships • Increasing networking • Building relationships • Improving communication • Increasing faculty engagement	(E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999) (Owen-Smith, 2001) (D. S. Siegel, Waldman, David, Link, Albert 2003a) (Mustar, 2006) (Tahvanainen, 2008) (D. Wright, 2013) (Dahl, 2015)

Table 3. Continued. Non-HBCU Technology Transfer Needs

Proposed Tool	Challenge	Reference
Benchmarking Tool	Need quality faculty by measures such as NRC's	(Friedman, 2003) (J. B. Powers, 2003) (O'Shea, 2005)
Model University IP Policy	Need faculty that is willing to be continually involved in tech transfer with service such as: • Consulting arrangements with licensees • Technical adviser • Marketing adviser • Business adviser	(Friedman, 2003) (D. S. Siegel, Waldman, David, Link, Albert 2003a; M. Wright, Burley, Sue, Mosey, Simon, 2004; M. B. Wright, Sue; Mosey, Simon 2004)
Budget Resource Planning Tool	TTO needs clear goals, priorities, resource planning and planned investments of their financial resources	(Friedman, 2003) (D. S. Siegel, Waldman, David, Link, Albert 2003a) (Van Hoorebeek, 2004)
Model University IP Policy	Venture capital	(S. Shane, 2002) (D. S. Siegel, Waldman, David, Link, Albert 2003a)
Model University IP Policy	Spend more time on grants related research to increase tech transfer	(A. N. S. Link, Donald S.; Bozeman,Barry 2007)
Model University IP Policy	Tenured faculty with successful research programs are more likely to engage in tech transfer	(A. N. Link, Siegel, Donald S., Bozeman, Barry 2007; A. N. S. Link, Donald S.. 2007)
Model University IP Policy	Equity licensing needs to be embraced: • TTOs should engage in equity licensing rather than seeking cash from start-ups • TTOs should seek lower royalties from start-ups	(E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999) (G. D. G. Markman, Peter T.; Phan, Phillip H.; Balkin, David B. , 2005; S. Shane, 2002; S. S. Shane, Toby, 2002) (Di Gregorio, 2003) (G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005)

Table 3. Continued. Non-HBCU Technology Transfer Needs

Proposed Tool	Challenge	Reference
Benchmarking Tool, Budget Resource Planning and Model University IP Policy	TTO needs to be adequately resourced: • Legal budget • Well compensated TTO staff • In-house venture capital program (esp. for medical related inventions) • Presence of a Business Incubator	(S. Shane, 2002; S. S. Shane, Toby, 2002; D. S. Siegel, Waldman, David, Link, Albert 2003a) (Degroof, 2004)
Model University IP Policy	Existence of a medical school [or] health science medical research results such as in: • Pharmaceuticals • Biomed because the royalties are hefty	(M. B. Wright, Sue; Mosey, Simon 2004)
Model University IP Policy	TTO need to be selective and prioritize the type of technology they will invest in such as: • Software • Biotech • Electrical engineering because these are easier to license	(M. B. Wright, Sue; Mosey, Simon 2004)
Model University IP Policy	Universities need to seek increased research funding in these areas: • Engineering • Life sciences • Chemistry • Information Technology	(O'Shea, 2005)
Model University IP Policy	Faculty researchers need to be adequately rewarded and incentivized to participate in university tech transfer • Royalty sharing • Credit toward promotion	(D. S. Siegel, Waldman, David, Link, Albert 2003a) (Friedman, 2003) (Lach, 2004) (D. S. P. Siegel, Philip Phan, 2005) (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007; A. N. S. Link, Donald S.. 2007) (Lach, 2008)

Table 3. Continued. Non-HBCU Technology Transfer Needs

Proposed Tool	Challenge	Reference
Job Scheduling Tool	TTO job task processing delays	(Colwell, 2002) (Bercovitz, 2003) (G. D. G. Markman, Peter T.; Phan, Phillip H.; Balkin, David B. , 2005) (Baldini, 2008) (R. N. Feldman, Kris, 2008) (Kenney, 2009) (Cao, 2015)

Table 4. Literature Review Gap Analysis

Gaps in the existing research:	
1. measured level and extent of perceived university bureaucracy which thwarts commercialization of university technology;	
2. measured levels of turn-over of TTO staff;	
3. quality and experience of TTO staff in their ability to protect intellectual property, conduct business formation and business development with marketing and social networking with an entrepreneurial spirit;	
4. measured level and extent of industry's use of universities' disseminated know-how in the form of publications, patents and conference presentations;	
5. measured time management in the TTO office (i.e. the use of the licensing staff's time and amount of time actually spent on commercialization);	
6. measured use of business schools' expertise by the TTO staff and faculty researchers;	
7. measured amount of training that the TTO staff and faculty researchers receive in entrepreneurship, intellectual property protection, start-up formation, and commercialization techniques;	
8. measured amount of universities that actually have developed principles for creating academic spinoff businesses;	
9. measured level of continued involvement of faculty researchers in the commercialization process;	
10. measured increase of faculty researcher quality with respect to those capable of inventing patentable inventions and participating in the commercialization process;	✓
11. measured level and extent that TTOs treat small entrepreneurial tech start-ups in the same manner as larger corporations that they seek to license technology to;	
12. how to increase HBCU engagement in technology transfer;	✓
13. how the social comparison theory can be applied in university tech transfer to provide HBCUs with performance benchmarks;	✓
14. how HBCUs can optimize their tech transfer budget resource planning; and	✓
15. how HBCUs can reduce time delays in university technology transfer with an advanced optimization job scheduling tool.	✓

CHAPTER III
RESEARCH METHOD

3.1 Theoretical Framework

The purpose of this research is to use teachings from the literature review about technology transfer problems faced by non-HBCUs as the basis for the development of a tool kit that HBCU representatives can use to overcome those barriers. Based on the literature review, problems with university tech transfer include time delays, resource management, lack of resources, lack of resource planning, lack of goal setting, and lack of incentives for faculty to engage in tech transfer activities.

Theoretical frameworks provide a structure to support explanations for why research problems exist. The problem here is that there is a lack of HBCU engagement in tech transfer. Herein this study, the research methods will be structured within a novel theoretical framework for HBCU technology transfer research based on the exploration of the four (4) theories explored in the literature review. As shown in Figures 19a and 19b, an integration of the four (4) theories will be applied to the methods used to develop the toolkit.

Beginning with lessons learned from the social comparison theory, instead of studying what a top ranked well established research university such as Stanford, MIT, University of California

Berkeley, University of Illinois-Urbana Champaign or Georgia Tech is doing, this study will focus on what the emerging non-HBCUs are doing with their tech transfer programs. Three (3) of the primary lessons learned from the social comparison theory follows:

1. HBCUs should be compared to non-HBCUs of similar ability and geographic location. With respect to the social comparison of ability, individuals compare themselves with others that have similar abilities (Festinger, 1954). This comparison allows them to lessen their uncertainty and enhance or preserve their self-esteem. These comparisons are based on others who are in close physical proximity because such individuals are likely to be similar in key ways (Greenberg & Ashkanasy, 2007; Suls & Wheeler, 2000). Thus, physical geographic location matters.
2. Competition, cooperation and conforming are social evaluation strategies related to social rules for distributing rewards; and competitive social comparison is greatest when the comparer and other person are similar in ability (Stephen Dakin, 1981).
3. Any comparison needs to be specific with objectively measurable attributes so as to diminish biasness (Allison, 1989; Van Lange, 1991).

The Resource Based View teaches that if resources are so unique and not easy to copy, then they are sources of competitive advantage (Barney, 1991). In university technology transfer, these resources include but are not limited to the expertise of faculty and their issued patents. The proposed HBCU shift from a teaching orientation to a research orientation will require a paradigm shift. The Paradigm Effect Theory, as applied to HBCUs, informs that it will be difficult for HBCUs to notice the need to shift since their existing paradigm is strong (Barker, 1992; Kuhn, 1996). So, the HBCU leaders need to learn how to engage in strategic exploration to anticipate the future better (Barker, 1992).

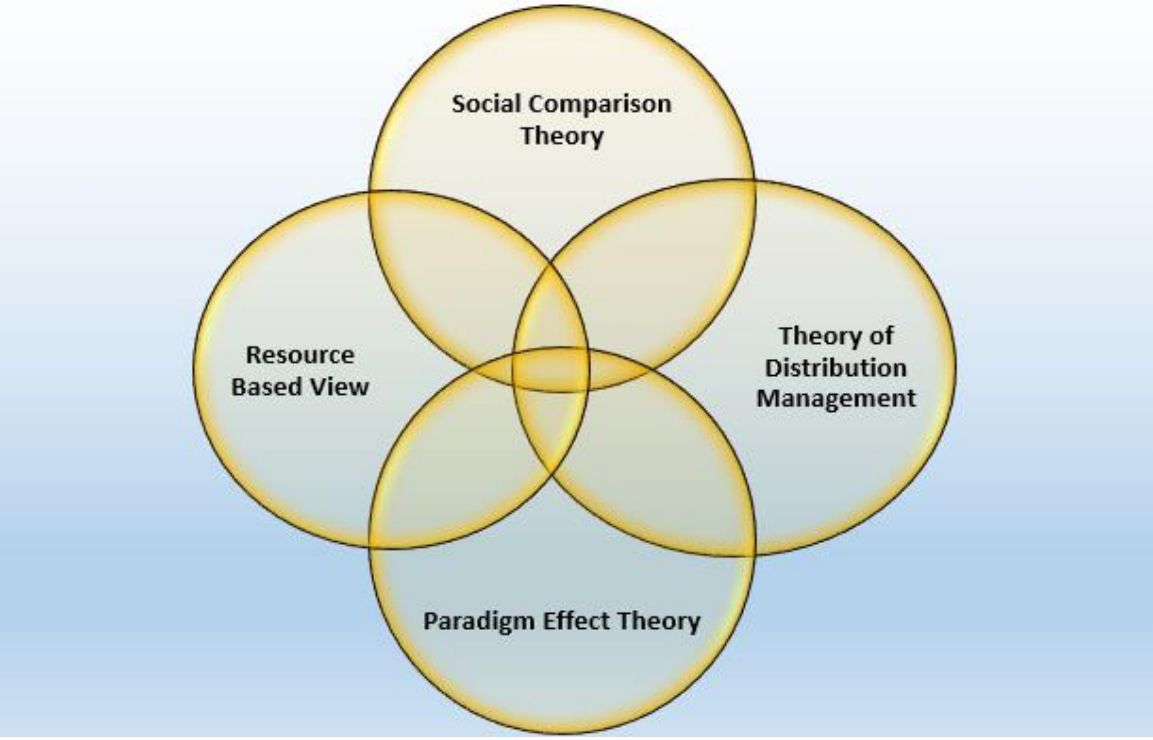


Figure 19a. **Theoretical Framework for the Proposed HBCU Tech Transfer Supply Chain Networks Research**

The Theory of Distribution Management provides the glue to meld these theories together into a framework. The Theory of Distribution Management teaches that because institutions are so interweaved, system dynamics influence product research, engineering, sales and promotion (Forrester, 1961, 1993). Systems Dynamics is the process of combining the theory, method and philosophy required to analyze the behavior of a system to provide a common foundation. University technology transfer can be viewed as supply chain distribution networks and therefore, are systems. The behavior of these systems need to be analyzed from a common foundation.

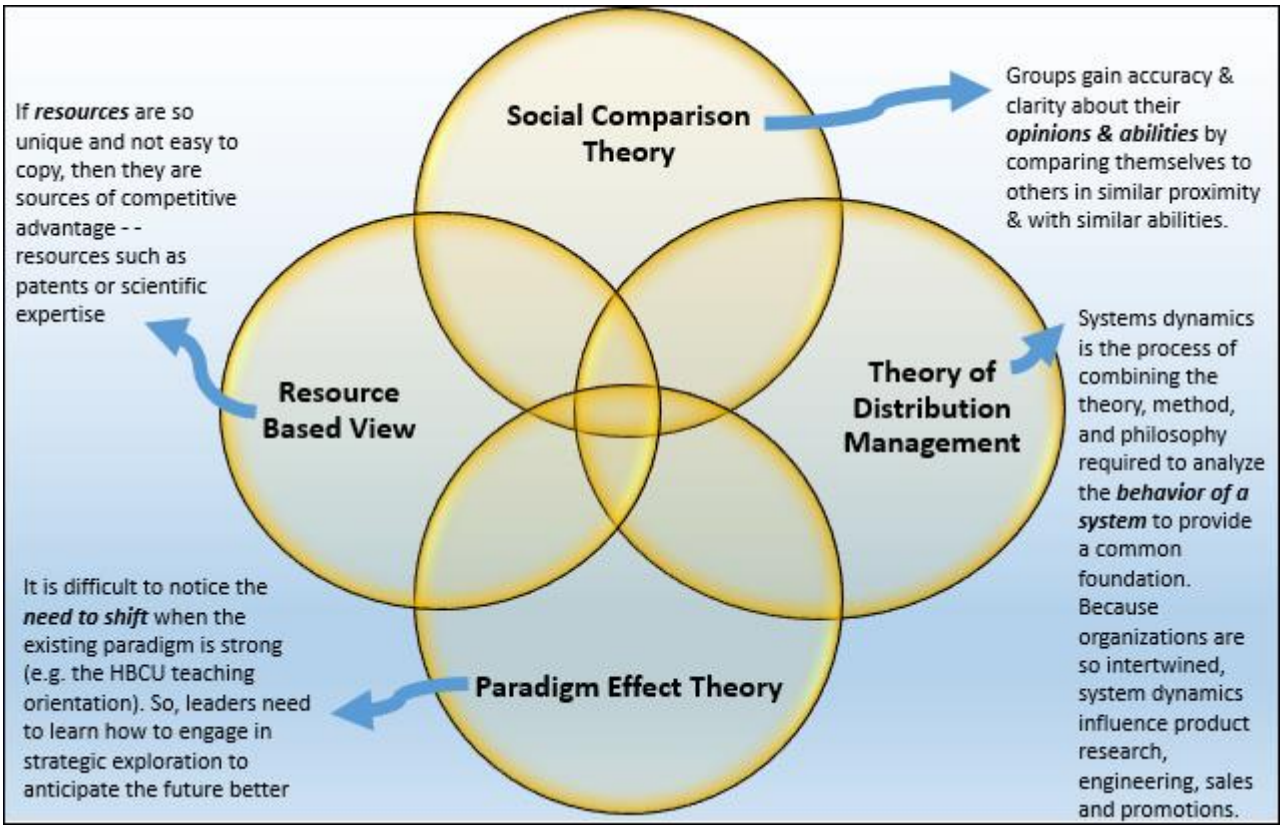


Figure 19b. Detailed Theoretical Framework for the Proposed HBCU Tech Transfer Supply Chain Networks Research

Alternative theories to the Social Comparison Theory component of this theoretical framework for this tech transfer research is the Attention Based View and Mindfulness. These theories were not chosen to be part of the theoretical framework for HBCU tech transfer research because the purpose of a theoretical framework is that it is to provide a structure to support explanations for why the HBCU research problems exists. The attention based view and mindfulness do not provide the close linkage to the HBCU problem as the social comparison theory. HBCUs are judged in comparison to non-HBCUs. There are upward and downward comparisons between HBCUs and non-HBCUs. The comparisons can be used to motivate HBCUs to improve their current research and tech transfer condition. Use of the attention based view or mindfulness is

not as apparent with respect to provide an adequate structure to support explanations of the HBCU study problem.

The emerging non-HBCU research institutions that the HBCUs can compare themselves to is defined as those identified in the NCES search. As noted in the Definitions of Key Terms section of this study, emerging non-HBCU research institutions are defined as those in the lowest quartile with respect to technology licensing revenues.

3.2 Research Approaches

This research approach section covers the approaches used to develop four (4) tools for a toolkit that HBCUs can use. There are 4 separate research approaches for each of the proposed performance benchmarking, budget resource planning, advanced optimization job scheduling, and model intellectual property (IP) policy tools. Figure 20 shows the four (4) problem areas identified in the literature review that are to be alleviated with these tools.

3.2.1 University Tech Transfer Benchmarking Tool Development

In this section, as shown in Figure 21, the research approach for the first of the four (4) proposed HBCU tech transfer tools is described. Here, the research and development of a benchmarking tool is explained.

As aforementioned in the National Academy of Engineering and National Research Council study of emerging institutions such as HBCUs, these institutions need a road map that includes metrics to gage progress ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009).

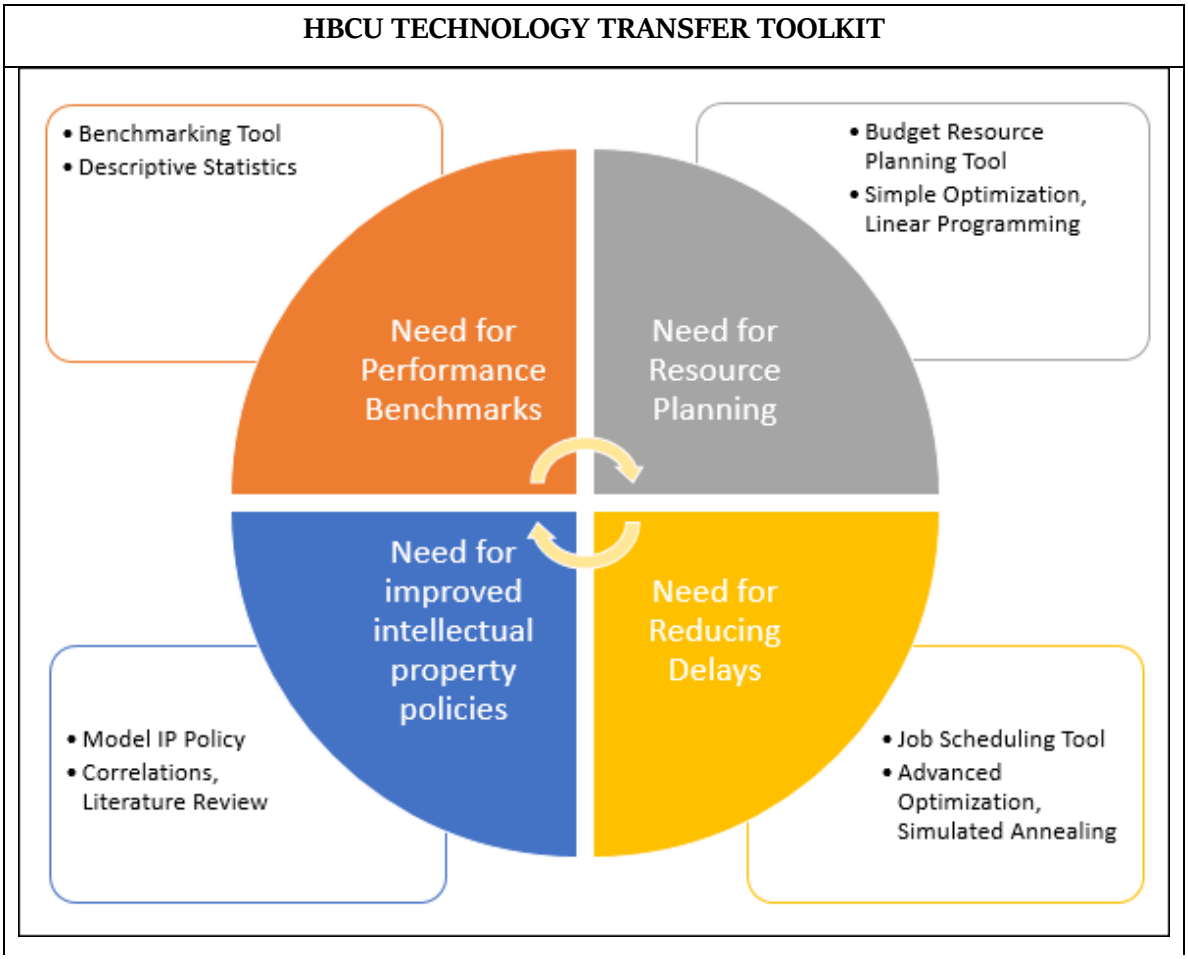


Figure 20. University Tech Transfer Problem Areas and Research Approaches

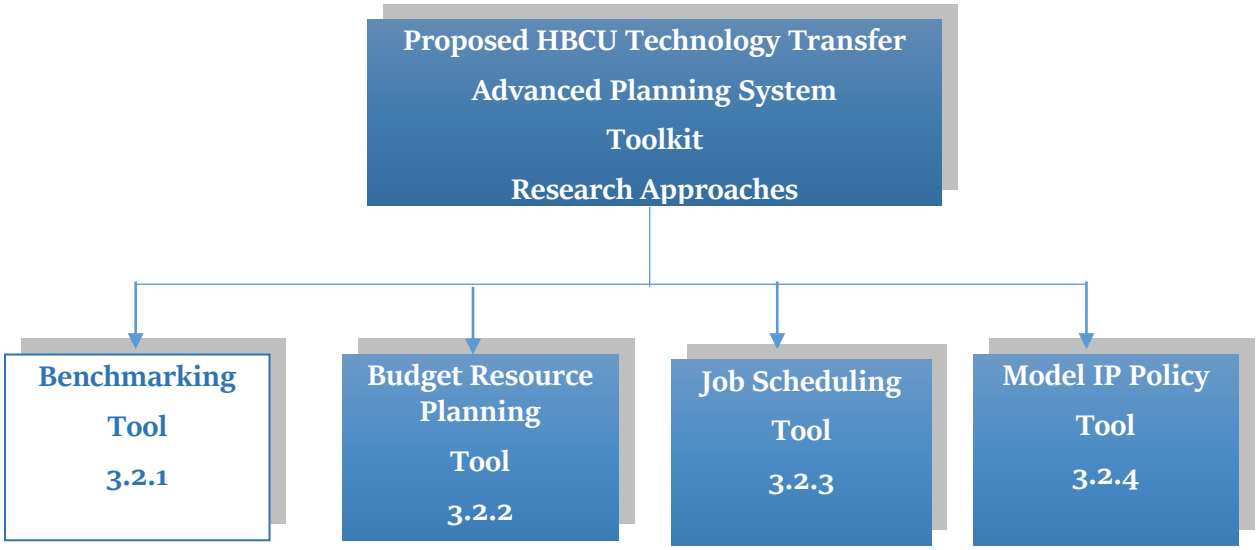


Figure 21. Benchmarking Tool Research Approach § 3.2.1

Benchmarking is a comparison with a standard as a measure of quality. Thus, in order to provide benchmarks for a university technology transfer supply chain network, standards for comparison must be established. When benchmarking, an organization compares its processes or proposed processes to another organization's processes.

In university tech transfer, benchmarking can be done for competitive purposes. If other universities are viewed as potential competitors for industry licensing deals, the competitor's value chain can determine the HBCUs response strategy (Fifer, 1989). For groups such as HBCUs, social comparison theory research states that benchmarking best serves as an evaluative tool (Hogg, 2000).

In 1993, an extensive study of tech transfer benchmarking best practices was conducted and the following six (6) core best practices were recommended as a tech transfer benchmarking framework:

1. Know the technological capabilities of the supplier (seller) of the technology. What does the supplier have to sell?
2. Know the nature of the marketplace and the technology needs of the customer (buyer) of the technology. What does the customer need?
3. Provide appropriate resources (both buyer and seller) to the technology transfer process.
4. Reward behavior that will drive current and future technology transfer success.
5. Formulate an organizational strategy in which technology transfer is recognized as a central mission.
6. Communicate this strategy, in the form of specific guidelines, policies and procedures, to all levels of the organization, and to the customers as well (L. K. G. Anderson, Brian D., 1993).

The benchmarking tool is important because the literature review revealed that TTOs need to be adequately resourced with, for example, adequate legal budget and other resources (Degroof, 2004; S. Shane, 2002; S. S. Shane, Toby, 2002; D. S. Siegel, Waldman, David A., Atwater, Leanne E., Link, Albert N. , 2003). This benchmarking tool will be a list of quality standards and performance metrics for which HBCUs can evaluate themselves by.

Step 1 – University technology transfer concept model development

Using a mixed method approach to research, the review of non-HBCUs university technology transfer literature was used to develop a concept model. The concept model is based on the ***Resource Based View*** theory portion of the theoretical framework. The concept model forms the university technology transfer supply chain network. Viewing university tech transfer as a ***Supply Chain Network*** is integral to applying the newly proposed theoretical framework for research described in Section 3.1.

Step 2 – Created a benchmarking tool template

The benchmarking tool was designed to form the portion of the university technology transfer supply chain network which focuses primarily on internal resources from the resource based view. External environment resources include only the industry and federal funding.

The goal was to analyze descriptive statistics and draw statistical inferences for inputs that impact licensing revenue. The licensing revenues and start up business outputs are also provided. These statistics provide the benchmarks.

Step 3 – Created a list of HBCUs with Doctoral programs

First, a list of HBCUs with Doctoral programs from the White House Initiatives' official listing of HBCUs was created. Next, the Carnegie Classification database was used to collect student enrollment data and geographic data about the HBCUs.

Step 4 – Created a list of non-HBCUs

The ***Social Comparison Theory*** portion of the theoretical framework was applied to establish criteria to determine the non-HBCUs to study. Lessons learned from the social comparison theory include that the non-HBCUs should be in the same geographic location (i.e. physical proximity) (Jerald Greenberg, 2007; Jerry Suls, 2000); and be of the same ability (Festinger, 1954) as the HBCUs relatively . In this study, geography is at the state level. Herein this study, ability is based on income generation ability. This is a combination of two potential income streams: (1) tuition and (2) gross licensing revenues. Student enrollment was used as the basis of tuition generation ability.

In tech transfer, universities are typically benchmarked against the best performing universities (DeVol, 2006). However, when applying the social comparison theory portion of the proposed theoretical framework for research, the benchmarking requires selecting non-HBCU universities

that are of similar size, ability and geographic location as the HBCUs. Herein this study, ability is based on student enrollment. Ability refers to financial ability as computed by tuition revenue and for simplicity, the tuition rate revenue is assumed constant between the HBCUs and non-HBCUs. The variable is student enrollment.

The following four (4) criteria was used to select the targeted non-HBCUs for HBCUs to compare themselves to:

1. Located in a state where the HBCUs with Doctoral programs are located;
2. Have student enrollment within the same range as the HBCUs with Doctoral programs;
3. Actively engaged in research and technology transfer; and participated in the AUTM Annual licensing survey for each of the five (5) years from 2010-2014; and
4. Considered to be 'emerging in tech transfer' licensing revenues as compared to all higher education institutions that participate in the AUTM Annual licensing survey with emergence defined as being in the lower quartile of gross licensing revenues.

Descriptive statistics about these selected non-HBCUs' technology transfer operations was computed.

Step 5 – Collected descriptive statistics for the selected non-HBCUs

For a period of five (5) years, statistical data was collected following the Resource Based View. Information about the selected non-HBCUs human resources, organizational resources and physical resources was collected. The university internal human resources were limited to Faculty and TTO staff. The National Academies of Sciences (NAS) National Research Council (NRC) Data-Based Assessment of Research Doctorate Programs in the United States for 2005-2006. The assessment serves to help universities improve their Doctoral program quality. This database was used to collect the following faculty quality standards:

- Number of publications per allocated faculty member and citations,

- % faculty with research grants,
- % faculty with honors and awards,
- % non-Asian minorities,
- % women,
- % faculty engaged in inter-disciplinary research,
- health science faculty size,
- % assistant professors, and
- % tenured professors.

AUTM data for TTO staff size data in full time equivalents (FTEs) was used. With regard to organizational resources, AUTM data was used to collect data on the select non-HBCUs' number of invention disclosures, patent applications filed and legal expenditures. The USPTO database was used to collect data on the number of patents the select non-HBCUs own. With respect to physical resources, AUTM data was to determine whether the select non-HBCUs have a medical school and engineering school.

For external resources, AUTM data to determine the select non-HBCUs' government funding and industry funding. Lastly, for outputs, AUTM data was used to determine the select non-HBCUs' number of licensing agreements, income from patent licensing, and number of startup businesses.

Step 6 – Add the descriptive statistics as benchmarks in the benchmarking tool

The median values of descriptive statistics were added to the benchmarking tool to provide the benchmarks for which HBCUs can use as a guide in establishing new university technology transfer supply chains or to grow their current operations.

This research is based on mixed-qualitative and quantitative methods. Qualitatively, based on the literature review, Figure 22 was developed as a preliminary concept model of University

Technology Transfer Supply Chain Network. It provides a comprehensive listing of inputs into the university technology transfer information processing system and shows that a measurable output is licensing revenue. The purpose of this study is to refine this comprehensive tech transfer supply chain network concept model based on information obtained about the select non-HBCUs which are more comparable in ability (based on lower licensing revenues) and geographic location to HBCUs. The result will be a benchmarking tool for HBCUs to use.

The proposed research method is to use a portion of the University Tech Transfer Supply Chain Network in Figure 22 for HBCU technology transfer as shown in Figure 23 to develop a benchmarking tool for HBCU leaders to use as a guide for university technology transfer. Note that in Figure 22 research expenditures are viewed as external resources available for universities to compete for. Yet, for the purpose of benchmarking, in Figure 23, research expenditures are viewed as internal resources for the universities to use. This is in alignment with the Resource Based View component of the theoretical framework for this research study.

Data Sources

The approach was to refine the Figure 23 university tech transfer supply chain network concept model by analyzing descriptive statistics and drawing statistical inferences using primarily five (5) database sources:

1) U.S. Department of Education's National Center for Education Statistics (NCES) tool for searching accredited schools and colleges ("Search for Schools and Colleges,");

2) Association of University Technology Managers (AUTM) Statistical Analysis for Tech Transfer (STATT) database ("AUTM STATT Annual Subscription,");

3) US Patent and Trademark Office (USPTO) Patent Full Text (PatFt) database (USPTO, 2016b);

4) The Academic Research and Development Expenditures FY 2009 (NSF, 2014a); and the

5) National Research Council (NRC) database assessment of research doctoral programs in the United States (NRC, 2011).

CARNEGIE CLASSIFICATION DATABASE

The database of Carnegie Classifications was used to identify the 2016 graduate program Carnegie classifications for all of the 101 HBCUs. The full listing is provided in Appendix A along with non-HBCUs located in the HBCUs' states. Figure 24 shows that, based on 2016 Carnegie Classifications, 45% of the HBCUs offer undergraduate degree programs, 32% offer post post-baccalaureate degree programs, and 23% offer Research doctoral degree programs.

A sample of 24 accredited HBCUs offering Carnegie classified Research Doctoral degree programs were drawn from the list of HBCUs reported by the White House Initiative on HBCUs. The US Department of Education's National Center for Education Statistics (NCES) search tool for schools and colleges was used to identify non-HBCU schools that are located in the same 17 states the select 24 HBCUs are located in. NCES provides student enrollment, type school (whether public or private), and geographic location.

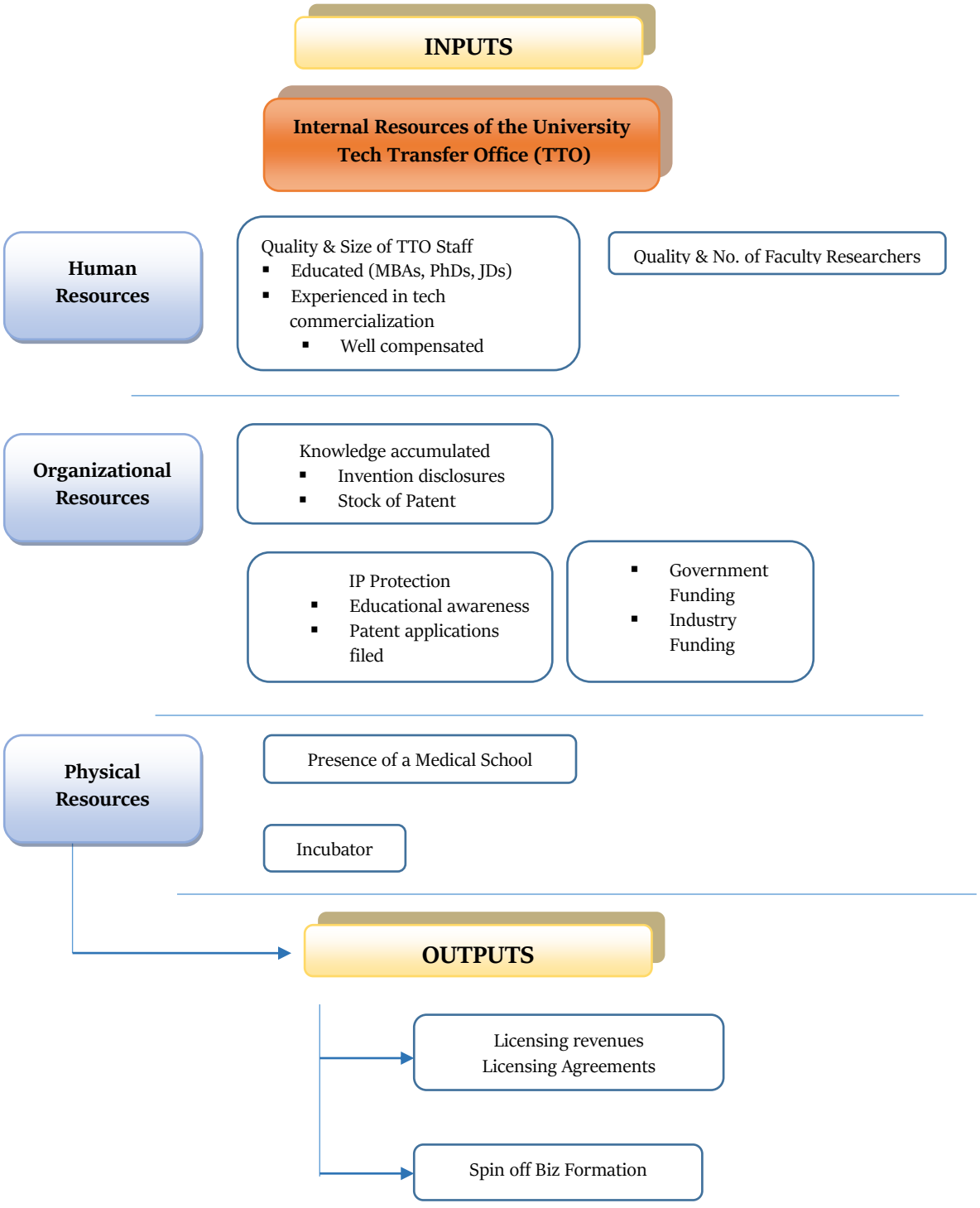


Figure 23. University Technology Transfer Supply Chain Network Concept Model

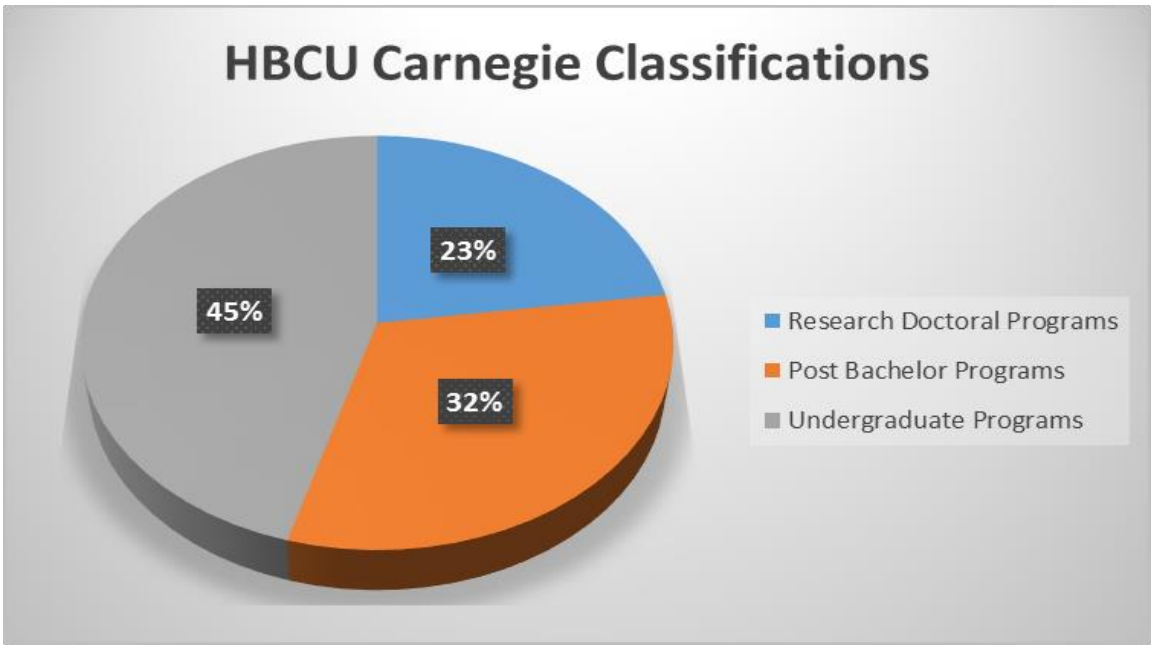


Figure 24. HBCU Carnegie Classifications

NATIONAL CENTER FOR EDUCATION STATISTICS (NCES) DATABASE

The NCES database was used to obtain student enrollment and location information for HBCUs and non-HBCUs located in the same state. The full listing is provided in Appendix A.

AUTM STATT DATABASE

The AUTM STATT database provides 20 years of data for the following data fields of information related to university Technology Transfer Office (TTO) resources and licensing performance.

Input resources include the following AUTM STATT database fields:

Lic FTEs – No. of Full Time Equivalent Licensing Staff in the TTO

Oth FTEs - No. of Full Time Equivalent Other Staff in the TTO

Tot Res Exp – Total Research Expenditures

Fed Res Exp – Federal funded Research Expenditures

Ind Res Exp – Industry funded Research Expenditures

Inv Dis – No. of Invention Disclosures

Tot Pat App Filed – No. of Patent Applications Filed

Output performance measures include the following AUTM STATT database fields:

Tot Lic Opt Exec – Total Licenses and Option Agreements Executed

St Ups Formed – No. of Start Up Businesses formed with the TTO's assistance

Gross Licensing Income

USPTO PATENT DATABASE

The USPTO's patent database was used to gather data on the number of patents owned by the non-HBCU institutions identified from the NCES search.

NATIONAL RESEARCH COUNCIL (NRC) FACULTY QUALITY DATA

The National Academies of Sciences' National Research Council (NRC) conducted a survey to assess American doctoral programs for years 2000-2006 and published its findings in 2011. The data includes measures of faculty quality per university program.

Characteristics included in the Faculty Weighting Process follows:

CATEGORY I—Program Faculty Quality
a. Number of publications (books, articles, etc.) per faculty member
b. Number of citations per faculty member
c. Receipt of extramural grants for research
d. Involvement in interdisciplinary work
e. Racial and ethnic diversity of the program faculty
f. Gender diversity of the program faculty
g. Reception by peers of a faculty member's work, as measured by honors and awards

BUREAU OF LABOR STATISTICS (BLS) DATABASE

The US Department of Labor's Bureau of Labor Statistics (BLS) database was used to find technology marketing staff salaries. The salaries are used in the budget resource planning tool development.

Next, more detailed information is provided about the framework of the proposed toolkit and its development. The following Sections 3.2.1, 3.2.2, 3.2.3 and 3.2.4 will discuss the benchmarking, budget resource planning, job scheduling; and Model IP Policy tool development.

3.2.2 University Tech Transfer Budget Resource Planning Tool Development

In this section, as shown in Figure 25, the second of the four (4) proposed tools for HBCU tech transfer is described. Here, the research and development for the budget resource planning tool is explained.

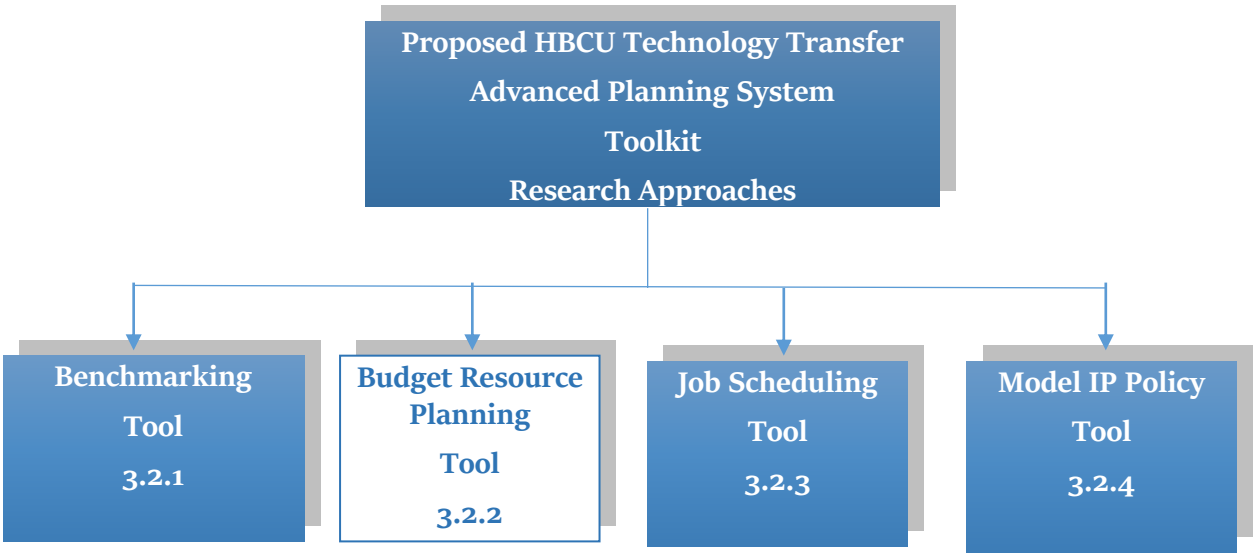


Figure 25. Budget Resource Planning Tool Research Approach § 3.2.2

Background

Financial resource planning is a best practice in tech transfer. Patenting and marketing to potential industry licenses is very expensive. This is a real problem and balancing act for TTO directors (Silverman, 2007). With each invention disclosure, TTOs must decide whether to invest funds, patent and market the technology quickly or they miss opportunities. A study of TTO directors revealed that 20.3% of the TTOs have to be self-sufficient and fund at least 50% of their operating budgets (Abrams, 2009). Thus, budget resource planning is crucial for all research universities and this is even more crucial an issue for budget strapped HBCUs. The level of resources committed to university tech transfer programs is the greatest determinant of success (Crowell, 2005).

The development of the proposed Budget Resource Planning Tool is important because the literature review revealed that the TTOs need clear goals, priorities, resource planning, and planned investments of their financial resources (Friedman, 2003; D. S. Siegel, Waldman, David A., Atwater, Leanne E., Link, Albert N. , 2003; Van Hoorebeek, 2004)[1]. This is even more imperative for emerging research institutions such as the HBCUs which have more limited resources.

Also, as aforementioned in the benchmarking tool development Section 3.2.1, The benchmarking tool is important because the literature review revealed that TTOs need to be adequately resourced with, for example, adequate:

- Legal budget,
- TTO staff compensation,
- In-house venture capital program (esp. for medical related inventions), and
- A business incubator (Degroof, 2004; S. Shane, 2002; S. S. Shane, Toby, 2002; D. S. Siegel,

[1] See Table 3 in the Literature Review Chapter II for the full listing of non-HBCU technology transfer challenges.

Waldman, David A., Atwater, Leanne E., Link, Albert N. , 2003).

It costs money to make money. Investments have to be made in providing and managing the necessary resources to operate a technology commercialization program successfully. The proposed Budget Resource Planning Tool is designed with the theoretical framework for research in mind. In particular, it was designed from the viewpoint that university technology transfer is a supply chain network. Herein this chapter section, the five (5) steps taken to develop the Budget Resource Planning Tool are described and include the:

1. development of the concept model for the university technology transfer supply chain network;
2. development of a licensing revenue optimization model;
3. collection of cost and supply capacity data;
4. experimentation; and
5. model validation.

Step 1 – Development of the concept model for university technology transfer supply chain network

The literature review was used to develop a concept model for a novel university technology supply chain network. Table 5 provides an analogy between the elements of a typical supply chain and the proposed tech transfer supply chain network. Figure 26 shows a proposed university technology transfer supply chain network.

A Supply Chain Network (SCN) is a master operational network involving geographically dispersed resources (Amaro, 2008). In the university tech transfer process, these resources come from geographically dispersed research centers on and off campus. This SCN also involves geographically dispersed market places. In university tech transfer, the geographically dispersed markets are represented by geographically dispersed industry partners.

Table 5. Typical Supply Chain vs. University Tech Transfer Supply Chain

Typical Supply Chain	Tech Transfer Supply Chain
Store	TTO store
Distribution Center	TTO distribution center
Plant	Research Labs
Customers	Industry Partners

The research labs' faculty inventors submit completed invention disclosure forms to the TTO distribution center. Once inventions are ready for tech commercialization, the TTO distribution center submits the invention to the TTO store as shown in the conceptual model for the university technology transfer supply chain network Figure 26.

The TTO store and distribution centers are ***Suppliers***. The literature review revealed that 72% of the TTOs have three (3) or fewer full time equivalent (FTE) staff members (Swamidass, 2009). The larger well regarded TTOs have staffs of 4 to 6.5 FTEs per $100 million of extramural research awards (Crowell, 2005). In the university technology transfer supply chain network, each TTO staff person can be a supplier that seeks to meet customer demands. The TTO staff may pitch patented inventions and travel to the potential industry partners; or these potential customers may come to the TTO store. Thus, their interchange is shown in Figure 27 as bidirectional. This is a dense network because each supplier can work to supply each industry partner customer's ***Demands***.

S_i, Suppliers are TTO staff persons

D_j, Industry partner customer demands

C_j, TTO invention capacity

C_{ij}, Cost that Suppliers i incur when interacting with customers j

$x_{ij,}$ Licensing deals

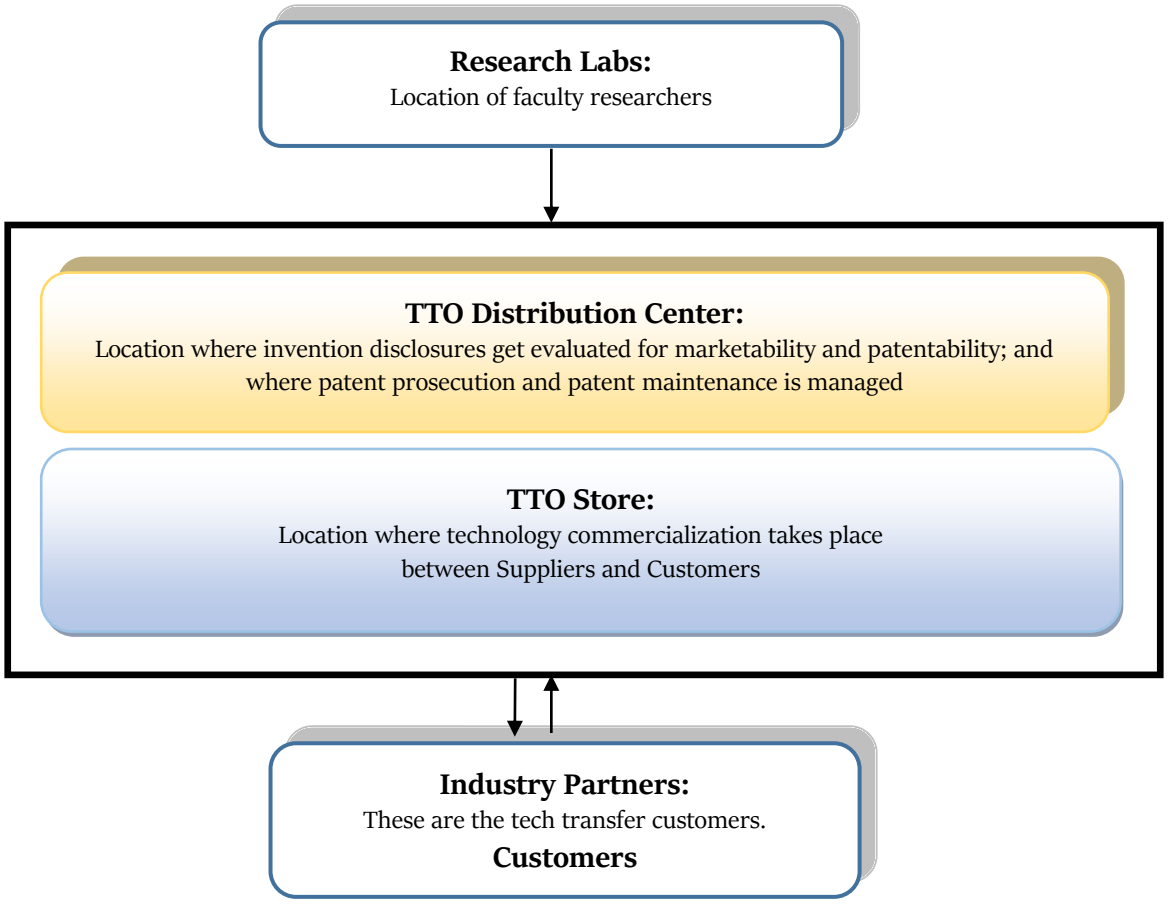


Figure 26. Conceptual Model for a University Tech Transfer Supply Chain Network

Common university tech transfer costs include the legal costs of patenting; and the TTO staff labor costs. The TTO staff persons are typically the individuals who work to negotiate licensing deals between their university and the industry partners that are seeking to license university technology. Figure 27 illustrates this university tech transfer supply chain network.

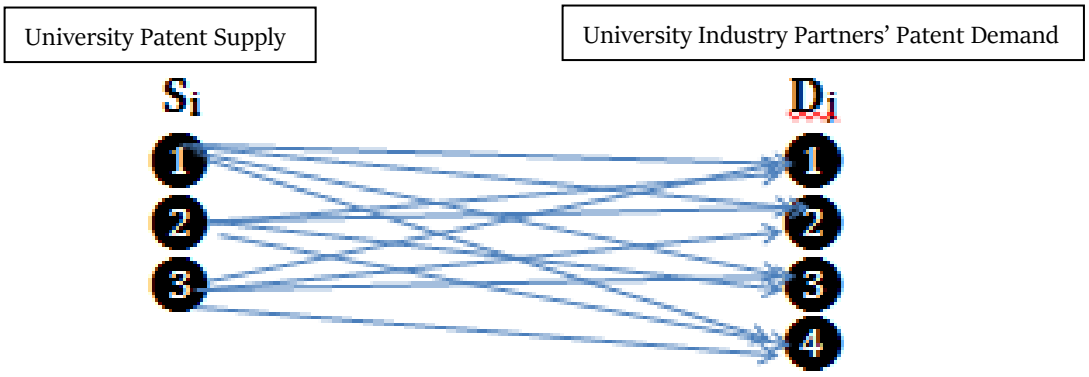


Figure 27. University Technology Transfer Supply Chain Network

Step 2 – Development of a licensing revenue optimization model

Using the classic supply chain warehouse shipment transportation model, a simple linear programming model was developed to maximize the licensing revenues between suppliers i and customers j in order for TTOs to recuperate licensing costs. The costs include TTO labor and patenting legal fees.

STEP 2A. THE CLASSIC WAREHOUSE SHIPMENT TRANSPORTATION MODEL

Before explaining the method used to develop a linear programming optimization tool to maximize university technology licensing revenues between the Suppliers i to the Customers j (i.e. Industry Partners) with Demands Dj, an explanation of the classic warehouse shipment transportation model is necessary. The classic supply chain warehouse shipment transportation model can be solved with Excel Solver as illustrated in Table 6.

Here are the variables in the Classic Transportation problem (Millar, 2013):

F_i – Fixed Costs

S_i – Supply

D_j – Demand from each customer

X_{ij} – the amount shipped from i to j

(i.e. from supplier i to customer j)

M = a large value = S_i

C_{ij} = unit transportation cost from i to j

Table 6. Classic Warehouse Shipment Transportation Network Design Problem in Supply Chain Management

	COSTS	CUSTOMER A	CUSTOMER B	CUSTOMER C	CUSTOMER D	SUPPLY from each warehouse
①	WAREHOUSE 1	0.6	0.56	0.22	0.4	10000
②	WAREHOUSE 2	0.36	0.3	0.28	0.58	15000
③	WAREHOUSE 3	0.65	0.68	0.55	0.42	15000
④	DEMAND	8000	10000	12000	9000	
	SHIPMENTS	**CUSTOMER A**	**CUSTOMER B**	**CUSTOMER C**	**CUSTOMER D**	**Row totals**
⑤	WAREHOUSE 1	0	0	10000	0	10000
⑥	WAREHOUSE 2	5000	10000	0	0	15000
⑦	WAREHOUSE 3	3000	0	2000	9000	14000
⑧	Column Totals	8000	10000	12000	9000	
⑨	Total cost	$13,830				

Source: (Millar, 2013)

The objective function is to minimize the transportation costs:

Min $\sum_i \sum_j$ Cij Xij + $\sum_i$ Fi Yi

s.t. the following constraints:

(1) $\sum_i$ Xij ≥ D_j

(i.e. amounts to be shipped from i to j need to be greater than the demand)

(2) $\sum_j$ Xij ≤ S_i

(i.e. amounts to be shipped from i to j need to be less than or equal to supplies)

(3) $\sum_j$ Xij – M Y_i ≤ 0

(i.e. if this is positive, this logical constraint, the M Y_i must be positive and Y_i must be equal to one)

X_{ij} ≥ 0

Y_i ∈ (0,1) 1 if the warehouse is opened and 0 otherwise.

Rows 1, 2 and 3 in Table 6 above contains transportation cost data for shipping supplies from Warehouses (i) 1, 2 and 3 to their destinations. The destinations are the Customers (j) A, B, C and D denoted by the columns in Table 6. The upper matrix simply supplies the cost information. For example, cell A1 = $0.6 to ship supplies from Warehouse 1 to Customer A.

The Supply column in the upper matrix provides the supply from each of the Warehouses. So, for example, Warehouse 1 can supply 10,000 units. The Demand row in the upper matrix provides each of the Customer's supply demands. For example, Customer A wants 8,000 units.

This linear programming model is a decision support optimization tool commonly used in supply chain management. The decisions to be made are located in the lower matrix denoted by rows 5, 6 and 7 for the three Warehouses and columns A, B, C, and D for the four Customers. The decision to be made is how much supply to ship from each Warehouse to each Customer. This

problem is solved using Excel Solver and provides an optimal solution based on a Simplex linear programming algorithm.

In Excel Solver, the total cost of shipments to all of the Customers from all of the Warehouses is minimized by changing the values of the cells in the lower matrix of Table 6. The Customer demands satisfied are computed and entered into Row 9. The row totals for the Warehouses rows 5, 6 and 7 are also computed and represent the amount shipped out of each Warehouse and received by the Customers.

Next, the constraints are specified in Excel Solver. The goal is to make sure that the amount received by the Customers is equal to or more than what is actually demanded. Recall that the Customer demand totals are in Table 6, Row 4. The total shipment amounts must be less than or equal to the amount of supply that is available. Lastly, unconstrained variables are made non-negative because a negative amount cannot be shipped. The Excel Solver solution is provided in Table 6. See cells A, B, C and D and rows 5, 6 and 7. The total minimized cost is provided in row 9.

Next, an explanation of how this can be used in technology licensing is provided.

STEP 2B. USING THE CLASSIC WAREHOUSE SHIPMENT TRANSPORTATION MODEL IN TECH LICENSING

Using the aforementioned classic supply chain warehouse transportation problem example, a similar linear programming optimization tool was developed with the purpose of maximizing patent licensing revenues in order to recuperate patenting and TTO staff labor costs. The patent licensing of university technology is between the Suppliers i (i.e. TTO staff licensing specialists) to the Customers j (i.e. Industry Partners) as follows:

S_i, Supplies are patented invention licensing deals

D_j, Customer demands

C_{ij}, Cost that Suppliers i incur when licensing the patented inventions to customers j

x_{ij}, Amount of patented invention licensing deals to be licensed between Supplier i and Customers j

Max $\sum_i \sum_j Cij\ Xij$

s.t. the following constraints:

$\sum_i Xij \geq D_j$

(i.e. amounts of patented inventions to be licensed from i to j need to be greater than the demand)

$\sum_j Xij \leq S_i$

(i.e. amounts of patented inventions to be licensed from i to j need to be less than or equal to supplies)

$X_{ij} \geq 0$

In addition, each supplier (i.e. licensing specialist) would realistic not close more than five (5) deals per year; and should close at least five (5). If there is at least one prospective customer per month out of the year (12 total), each would not likely license more than two (2) patents but would likely be interested in at least one (1).

This type of supply chain may be considered a service supply chain rather than a product supply chain. The next step in developing the budget resource planning tool is cost and supply capacity data collection.

Step 3 – Collection of cost and supply capacity data

Using the Social Comparison Theory component of the theoretical framework for this research study, nine (9) non-HBCU schools were identified and selected that HBCUs can emulate. Recall that the social comparison theory teaches that entities are most likely to emulate other entities that are in the same geographic location and that are of similar ability (Festinger, 1954). Here, ability is based on licensing revenue generation. The selected non-HBCUs are non-HBCUs in the lowest quartile of licensing revenues reported in the AUTM annual licensing survey.

Using the list of non-HBCUs selected in the development of the benchmarking tool, data was collected from the years 2010-2014 about legal expenditures, staff sizes, and total licensing deals from the AUTM database. In addition, salary information was collected from the US Department of Labor's Bureau of Labor Statistics database; and the number of patents was collected from the USPTO patents database.

The cost and supply data is comprised of the mean values for the non-HBCUs' legal fees, estimated labor expenses, and total number of patented inventions in inventory. The legal fees and labor expenses were summed to provide a total expense. This cost information provides evidence of what a licensing deal between a supplier and customer will likely cost.

Step 4– Experimentation

The cost and supply data for the select non-HBCUs was inputted into the budget resource planning tool linear programming model for experimentation. The mean total expense was divided among the three (3) hypothetical TTO staff persons who serve as suppliers; and among their 12 hypothetical customers who are the potential licensees. This value was entered as cost data the Microsoft Excel Solver linear programming optimization tool.

The mean value of the total patented inventions owned by the non-HBCUs was also divided between the three (3) TTO staff suppliers. This value was used as patent inventory. The benchmark for the number of licensing deals (determined once the benchmarking tool was developed) was used for the total demand from customers.

The customer demands are defined by the number of patented inventions customers are willing to license per year. Each customer would typically license one patented invention. Alternatively, the customer demands can be defined in terms of the amount of money they are willing to invest in a licensing deal. Microsoft Excel Solver was used to compute the optimum number of licensing deals given the objective of maximizing the TTO supplier revenue in an effort to recuperate patenting and TTO labor costs.

Step 5 – Model Validation

There are several approaches to model validation (Hills, 1999). In statistics, the standard method to estimate uncertainty is to perform the experiment multiple times and independently. "The scatter in the differences between model prediction and the experimental observation can be used to make estimates about the statistics of the uncertainty" (Hills, 1999). However, it can take a lot of time to run multiple experiments. Therefore, prediction uncertainty can be estimated through analysis. For example, one can calculate probability density functions estimates for model parameters with uncertainty that appreciably impacts the model predictions. A *propagation of uncertainty analysis* can be used to estimate model prediction uncertainty. Then, with testing, a decision can be made about whether the model predictions are statistically consistent with the observations in the experiment.

A *simple graphical comparison* between the simulated measurements and the model predictions using the mean values of the model parameters can be conducted (Hills, 1999). If significant

differences in the trend of the model predictions relative to the experimental results are visual, then there would not be much confidence that the model is valid.

In this study, model validation was achieved with a *scenario analysis* to depict the proposed model's feasibility. With scenario analyses, an example project is used to assess the model's capability and to validate the proposed model (Liu, 2007). Further, in the linear programming optimal solution may be unbounded or infeasible; multiple solutions may be found; or there might be degeneracy. The following steps are tools that can be taken to validate the model (Arsham, 2016):

- If unbounded, to resolve there must be a check on the formulation of the constraints to see if one or more constraints are missing or mis-specified.
- If there are multiple optimal solutions, to resolve, the coefficients in the objective function and the constraint need to be checked. Also, there could have been rounding errors.
- If there is no solution, the model may need to be reformulated after checking the constraints' formulations to see if there are missing or mis-specified constraints.

In addition, the sensitivity ranges for linear programming problems may be computed. In lieu of computing sensitivity ranges, *Monte Carlo testing* can be conducted to evaluate uncertainty (Hills, 1999). An acceptance region can be defined for differences between the experimental observations and model predictions for single measurements.

An experiment was conducted involving use of the Microsoft Excel Solver Simplex LP optimization tool to compute the optimal number of inventions to licenses to each customer with the objective to maximize licensing revenues. The results of the experimentation can be found in Chapter IV, Section 4.2.

Next, in Section 3.2.3, the development of a university tech transfer job scheduling tool is discussed.

3.2.3 University Tech Transfer Job Scheduling Tool Development

This section describes the research method for the third HBCU tech transfer tool. Here, as noted in Figure 28, the research approach for the university tech transfer job scheduling tool's development is described.

Background

The proposed Job Scheduling Tool is important because the literature review revealed that the well-established non-HBCUs' TTOs experience job task processing delays (Baldini, 2008; Bercovitz, 2003; Cao, 2015; Colwell, 2002; R. N. Feldman, Kris, 2008; "HBCU Innovation and Entrepreneurship Collaborative," 2014; Kenney, 2009; G. D. G. Markman, Peter T.; Phan, Phillip H.; Balkin, David B. , 2005)[2]. Despite these delays, these TTOs still earn licensing revenues. Nevertheless, the HBCUs may face the same challenges.

As a supply chain network, university technology transfer involves changes in patent supplies and demands for patent licenses from customers. The best value supply chains are agile and able to act swiftly in response to supply and demand changes (Ketchen, 2008). Significant delays in the TTOs' evaluation of faculty researchers' invention disclosures can thwart opportunities for faculty researchers to publish their research findings. In order to avoid publication delays, the literature review revealed that faculty may not submit their invention disclosures at all (Bercovitz, 2003; Cao, 2015). Once the word gets out that there are delays caused by the TTO, the word spreads

[2] See Table 3 in the Literature Review Chapter II for the full listing of non-HBCU technology transfer challenges.

among faculty quickly and this can have devastating effects on the invention disclosure rates (Tahvanainen, 2008).

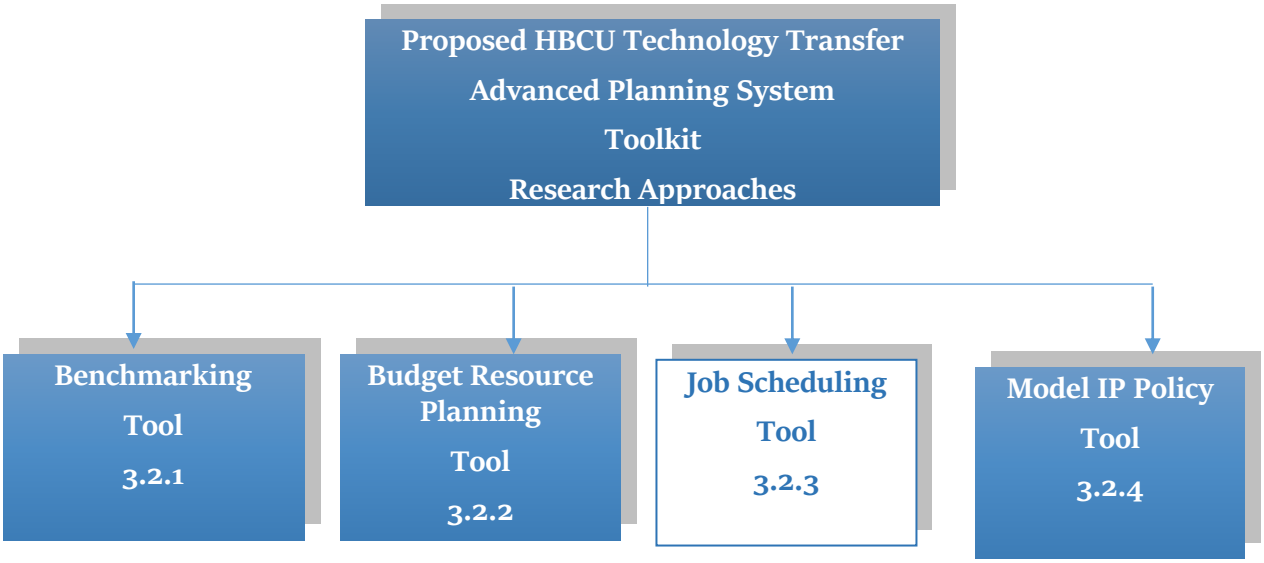


Figure 28. Job Scheduling Tool in the Advanced Planning System.

The sentiment in the tech transfer profession is that tech transfer occurs best in a flexible office that does not crack under pressure and offers employees work autonomy (B. C. Bozeman, Karen, 1992). The closest that the profession has come with respect to measuring tech transfer effectiveness is to measure outputs of what goes out the door (i.e. patent applications, licensing agreement, business formations) (B. R. Bozeman, Heather; Youtie, Jan, 2015) rather than timeliness.

So, job task scheduling is not commonplace in university TTOs. In 2009, Spivey et al. advocated that an alliance score card be used to improved established roles and responsibilities; and to identify misplacements or disconnects between core competencies, value propositions for customers, and technology commercialization conventions. Although delivery delays were

mentioned, there was no mention of the importance of job scheduling other than advocating honoring a commitment to keep on schedule (Spivey, 2009).

The lack of use of job scheduling in tech transfer may be due to the fact that commercially available job scheduling software tools may be perceived as too hard and time-consuming to learn and use. Job scheduling can be complex, difficult and time-consuming (Bahouth, 2014). Thus, there is a need for a simple and easy to use job scheduling tool that TTOs can use.

The development of the proposed Job Scheduling Tool serves to help combat the problem of tech transfer task processing delays faced by non-HBCUs. Advanced optimization is a technique used more and more in industrial engineering; and in other science and engineering fields. It is proposed that advanced optimization can be used to provide a very simple tool to schedule tech transfer job tasks. With advanced optimization and process understanding, the technology transfer process can be efficient and repeatable (Schmidt, 2011).

Herein, the following four (4) steps in developing the Job Scheduling Tool is described and includes the:

1. development of a list of TTO job tasks to schedule;
2. development of a job scheduling algorithm with the use of simulated annealing;
3. experimentation; and
4. comparison of a job schedule created with a commercially available software program to the newly developed simulated annealing job scheduling tool.

Step 1 – Development of a list of TTO job tasks to schedule

The literature review was used to create a university technology transfer process flow and to identify typical TTO job tasks that need to be scheduled. The number of TTO FTEs identified in the benchmarking tool was used for the TTO staff size. Since 72% of the TTOs have 3 or fewer

FTE staff members (Swamidass, 2009), an experiment was designed to schedule job tasks for 3 staff persons. Figure 29 illustrates the university technology transfer process flow. This process flow identifies the following university tech transfer job tasks which are typically conducted by TTO staff the:

- delivery of training seminars,
- evaluation of invention disclosures;
- review of outside patent counsel's patent prosecution documentation; and
- creation of marketing plans.

Step 2 – Development a job scheduling algorithm using Simulated Annealing

In order to develop a simple job scheduling tool for HBCUs to use, an algorithm was developed using the advanced optimization technique of simulated annealing. Simulated annealing is an optimization technique based on the crystallization process (Kurbel, 2013). A substance gets slowly cooled after it is heated to a very high temperature. Perfect crystals are formed once the minimum energy is reached. In a simulation of this annealing process, the algorithm begins "with an initial solution, modifies the solution, and then continuously creates further solutions. These solutions are accepted for the next iteration with a certain probability. The probability depends on a parameter called "temperature", as in … real annealing" (Kurbel, 2013). With each iteration, the temperature is reduced. Since cooling down slowly increases the computing time, a trade-off between solution quality and computing time has to be made. Simulated annealing was also chosen because this heuristic approach can be used to find optimal solutions at a low computational cost (Hedjazi, 2015; Ohsaki, 2010). Heuristic scheduling has been studied and advocated since the late 1970s (Kanet, 1991). When applied to detailed scheduling, simulated annealing performs well (Kurbel, 2013).

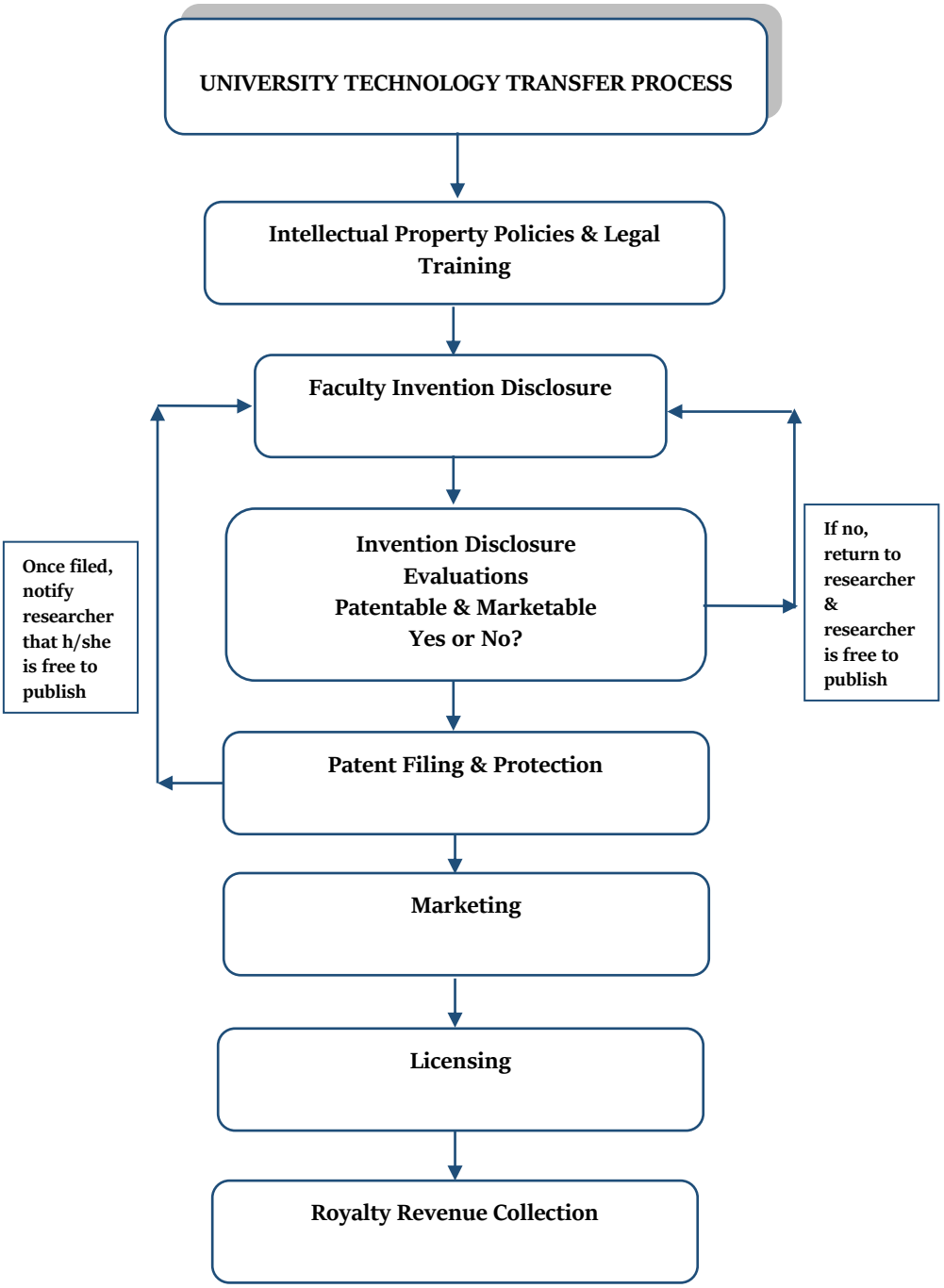


Figure 29. University Technology Transfer Process Flow

Simulated annealing has been proven to be able to find the global optimum solution within the entire domain of a function, rather than just a local optimum solution (Goffe, 1993). Benefits of simulated annealing include:

1. it can process functions that possess “arbitrary degrees of nonlinearities, discontinuities, and stochasticity;
2. it can process quite arbitrary boundary conditions and constraints imposed on these functions;
3. it is easy to implement with the degree of coding quite minimal relative to other nonlinear optimization algorithms; and
4. it can statistically guarantee finding an optimal solution” (Ingber, 1993).

Therefore, simulated annealing is a promising direct metaheuristic approach to reaching acceptable solutions to general scheduling problems (Bahouth, 2014).

A flow chart of the algorithm is provided in Figure 30 and the variables are listed in Table 7. The goal is to minimize job delays in university tech transfer with an advanced optimization job scheduling tool. The objective function h(x) has a "domain", which is basically the collection of all possible values that have an outcome. The domain is all possible combinations of job assignments. The domain is depicted on the X axis. The values of h(x) are on the Y axis. The objective is to find the x for which h(x) has an optimal value by minimizing the squared difference between the amount of time a person has to work and the 8 hours they should work:

$$z = \sum\left(\frac{dur.per.pers}{8hrs}\right)^2$$

The algorithm's control flow is provided in Figure 31. This simulated annealing control flow is motivated by instructions provided in Zapfel et al.'s metaheuristic search concepts (Zapfel, 2010). The goal of the algorithm is to find that point x in the domain for which h(x) has the maximum value. The classical approach is to:

1. take a combination and calculate h(x);
2. take a set of neighboring combinations (for example by switching a single job) and calculating h(x) for those;

This is known as "hill climbing" because you start somewhere on the function h and just climb up to higher regions. But, at a local maximum, the algorithm will stop there and never reach the global maximum. The simulated annealing algorithm takes care of that, by allowing the algorithm to jump back to "worse" states sometimes and move from there. This results in the algorithm going to a completely different spot on the h graph and start climbing again. That way it has a bigger chance of arriving at or close to the global maximum.

There is a draw-back. If the algorithm is allowed to always jump back to worse states, it might keep on jumping around and never reach any maximum at all. So, in the beginning, the algorithm is allowed to jump basically anywhere. However, it is restricting further and further. This is the "temperature" in the annealing process which is a measure of how much "worse" of a state can be to be accepted.

The worse state is not allowed to be selected. It is merely given a certain chance to be selected. This is typically depicted as a probability rho = exp (delta h / temp). The "cooling down" of the temperature just makes it less and less likely for a worse state to be selected.

In the algorithm, two (2) things are tracked the:

1. best solution so far, and
2. current solution so far.

The objective function is calculated. If the solution is better or slightly worse, the new solution is taken as the current state. Otherwise, the state is kept as is. If there is a switch to the new solution as the current state, a check is made on whether there is a new best solution.

Table 7. Job scheduling algorithm terminology and variables

Domain x	X axis which is the collection of all possible combinations of job assignments that have an outcome
h(x)	Y axis
Local maximum	A given range for the location of the maximum value of the function
Global maximum	The maximum located in the entire domain of the function
Temperature	In the simulation of the annealing process, the temperature restricts the algorithm from jumping around anywhere. It is a measure of how much worse a state can be accepted. The temperature gets cooled down to make it less and less likely for the worse state to get selected.
Best solution	Lowest value for the objective function
Current solution	current state of the objective function value
Variables	
dur	Vector with durations
ndur	Length of durations vector
pers	Vector of TTO staff person
npers	No. of persons in the TTO staff
dur.per.pers	Total duration for each person
disturb	This is delta h which is the amount of disturbance which is a measure of the likeliness that a worse solution is selected. See explanation below.

Table 7. Continued. Job scheduling algorithm terminology and variables

rho, ρ	% chance allowed for h(x) to be in its worse state = exp (delta h/ temp) Thus, temp * log(rho) = delta h The formula for rho includes a temperature This is done with the runif command in R since it takes a random probability between 0 and 1 and multiplies it with temp to get *disturb*, a value which is always between 1 and 0. Runif is always smaller than 1. So, its logarithm is always smaller than zero.
iter	No. of iterations; used 1 x 10^4 = 100,000; begin at 1
scale	Scaling factor for the probability = 0.8
unchanged	Begin at zero
max.unchanged	Maximum number of iterations where best solution can remain unchanged 1 x 10^3 = 10,000 (i.e. there is convergence)
state	Current state begins with *best* variable's value
h_state	Begins with h_best value
best	The initial best solution of randomly assigned jobs
hbest	Vector to sample from
h_best	Calculated with the objective function using the durations computed from the variables *dur* and *best*
h_diff	(h_state – h_current) * scale
temp	Begins with value 1. The temperature moves closer and closer to zero in the plot of disturbance values. The more iterations, the closer it moves to zero.
Jobs	Data frame of job and time information
Job	Vector of job task names
time	Vector of job task times

Algorithm – Simulated Annealing Job Scheduling Tool Control Flow

```
Generate initial solution;
Assign initial temperature
Assign number of iterations at each temperature level

while termination criteria are not satisfied, do
    for i=1 to iter do
        Generate new neighbor s' by randomly sampling the set of possible job tasks;
        Compute Δ h = h_state – h_current;
        if
            Switch over to solution x' (current solution s is replaced by s');
        else
            Generate random number r in ∈ [0,1];
            if r ≤ exp(-Δ h/ T_k ) then
                Switch over to solution s' (current solution s is replaced by s');
            end
        end
    end
    Update the best solution if appropriate;
    Set k <- k+1
    Set l Update temperature value T_k for the next level k
end
return Best solution.
```

This allows two (2) things:

1. Overall, the best solution improves the whole time from the start state; and
2. It can also become a worse solution. This worse solution is then the start for a new iteration, and allows the algorithm to explore options further away from the current best solution.

The flow chart for the simulated annealing algorithm is provided in Figure 30.

Step 3 – Experimentation

The problem scenario is that three (3) TTO staff persons should work 8 hours each = 24 hours total. But, there's 26 hours work of worth. Also, if the team cannot work 24 hours, then the *mean duration* per person has to minimized. With simulation, the goal was to minimize the absolute value of deviation between completion time and due date. Table 8 provides 11 hypothetical job tasks, estimated completion times, and deadlines for the three (3) TTO staff persons to complete.

The meta-heuristic method of simulated annealing was used carried out using R programming. Here are the assumptions:

- All 11 jobs are available at time t=0. This is assumed to be the work start time on December 1, 2015. The jobs can be carried out independently, each by one person.

  Completion times of jobs i are denoted by C_i, i=1…11 and the corresponding due times by D_i, i=1…11. The due times are the days until deadlines multiplied by 8 hours work per day.
- The objective function to minimize is the total number of delays.

$$Z = \sum_1^{11} \min\left(0, \frac{C_i - D_i}{|C_i - D_i|}\right)$$

- An alternative objective function is the total idle time. This is defined as the sum of the times each supplier waits after he/she finishes, until all jobs have been completed.
- To account for varying speeds of the TTO staff persons (i.e. suppliers), if t_1, t_2…t_{11} are the processing times required by Supplier #1 for the 11 jobs, the processing times for Person #2 are $2t_1$, $2t_2$, …, $2t_{11}$ and the ones for Supplier #3 are $3t_1$, $3t_2$, …, $3t_{11}$.

Table 8. Job scheduling tool simulated job tasks and deadlines

Total of 11 jobs	Estimated time to complete (hrs. each)	Total estimated required time (hrs.)	Deadlines	Day in the Month
Complete 3 separate training seminars in 3 different colleges	4	12	December 1 December 4 December 6	1 4 6
Evaluate 3 separate invention disclosures	2	6	December 3 December 3 December 4	3 3 4
Review patent prosecution documentation from outside patent counsel regarding 2 different inventions	1	2	December 2 December 4	2 4
Create marketing plans for 3 different patented inventions	2	6	December 1 December 4 December 4	1 4 4
		26		

Step 4 – Comparison of the job schedule using a commercially available Excel solver tool to the newly developed simulated annealing tool

Finally, the advanced optimization job scheduling tool based on simulated annealing was compared to a commercially available Excel Solver job scheduling tool.

Next, in Section 3.2.4, the proposed university technology transfer Model IP Policy tool's development will be discussed.

3.2.4 University Tech Transfer Model IP Policy Development

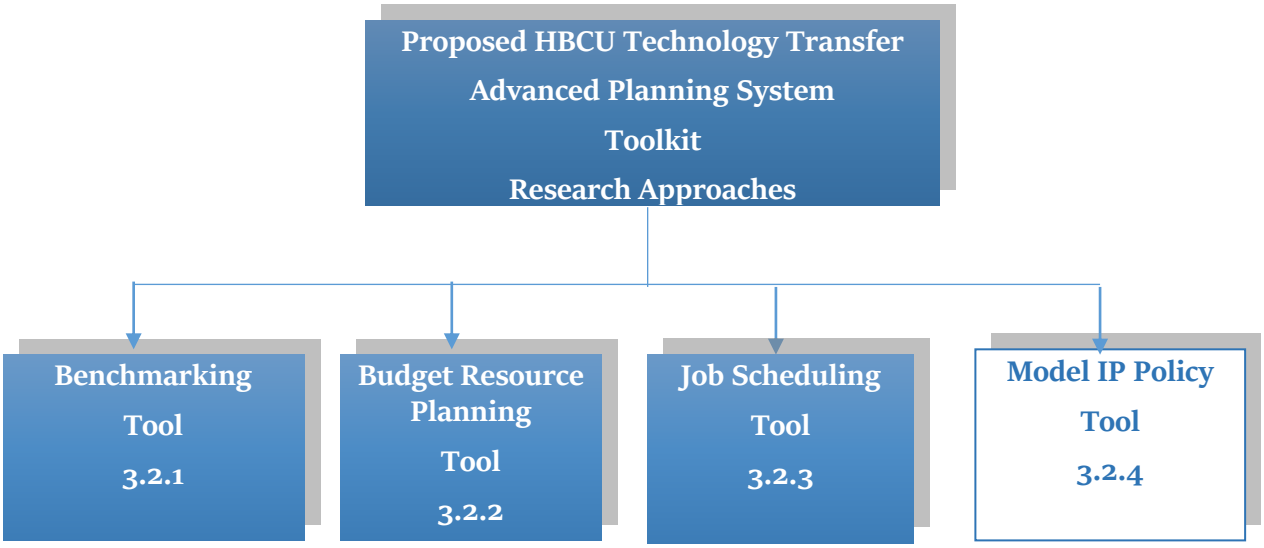


Figure 32. Model IP Policy Tool Research Approach § 3.2.4

This is a mixed-methods study. The Model IP Policy tool is created using a combination of information from the comprehensive literature review and statistical inferences gleaned from

correlations. This section explains the three (3) steps in the Model IP Policy tool development which include:

1. summarizing the best policies found in the literature review;
2. determining the relationships between variables in the university tech transfer process by conducting a correlation analysis; and
3. drafting a Model IP Policy.

Step 1 - Summarizing the best policies found in the literature review

The first step is to develop a list of IP policies that address the list of non-HBCU technology transfer needs. The list is located in the Chapter II, Table 3 literature review summary. As aforementioned, the challenges that are currently faced by non-HBCUs will likely be faced by the HBCUs. Therefore, the HBCUs should shore up and improve their IP Policies in order to address these issues.

Step 2– Conducting a correlation analysis to determine the relationship between variables in the university tech transfer process

Correlations provide a means to assess how strongly any two variables are related. Correlations provide a way to predict future behavior of variables based on past observations. Using Microsoft Excel's Data Analysis tool, correlation coefficients were computed with Excel's CORREL function for the AUTM STATT database and NRC faculty quality assessment database fields.

The correlation coefficient is a number between -1 and +1 which ascertains the degree of association or 'strength' between two variables on the scale of -1 to +1 (Kirk, 2007). Like the covariance, the correlation coefficient is used to ascertain the degree to which two variables "vary together". Unlike the covariance, in order for its value to be independent of the variables' units, the correlation coefficient is scaled (Microsoft, 2016).

A correlation coefficient of +1 suggests a perfect positive correlation. This means that when "variable X increases, variable Y increases. Likewise, when variable X decreases, variable Y decreases. If the correlation coefficient is -1, then this is a perfectly negative correlation. So, as variable X increases, variable Y decreases; or if variable X decreases, variable Y increases. A correlation coefficient of zero indicates no correlation" (Kirk, 2007).

Microsoft Excel's CORREL function calculates the "Pearson Product-Moment Correlation Coefficient for two sets of values x and y using:

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

The *x* and *y* values are the sample means of two arrays of values and have the syntax:

CORREL (array1, array2)

where array1 is a set of independent variables and array2 is a set of dependent variables. These arrays should be of equal length" (ExcelFunctions.net).

Note that data from AUTM, NRC and the USPTO was used to identify benchmarks for the key attributes of the proposed HBCU Tech Transfer model. Next, a complete description of the data sources is provided.

The findings from the correlations will provide insightful predictions about the relationships between variables related to university tech transfer given observations from the select non-HBCUs that HBCUs can compare themselves to. These insights will provide useful guidelines for what to include in the Model IP Policy tool.

This concludes the Research Approach Chapter III. Next, the findings for the development of all four (4) tools - - i.e. benchmarking, budget resource planning, job scheduling and Model IP Policy are provided in the following *Results and Discussion Chapter IV*.

Step 3 – Drafting a Model IP Policy

One of the exercises in the Benchmarking tool development is the study of the HBCUs' and non-HBCUs' IP policies. From these policies, the policy statements that will be used in the Model IP Policy will be the policies that reflect the best practices identified in (1) the literature review and (2) the correlation analysis.

This concludes the Research Approach Chapter III. Next, the findings for the development of all four (4) tools: (1) benchmarking, budget resource planning, job scheduling, and Model IP Policy development are provided in the following Results and Discussion Chapter IV.

CHAPTER IV
RESULTS AND DISCUSSION

The results of the research conducted to develop each proposed HBCU tech transfer tool is discussed in this chapter. Sections 4.1, 4.2, 4.3 and 4.4 present the findings for the Benchmarking, Budget Resource Planning, Job Task Scheduling, and Model IP Policy tool development respectively.

4.1 HBCU Tech Transfer Benchmarking Tool Development Results

As noted in Figure 33, this section provides the results of the benchmarking tool development.

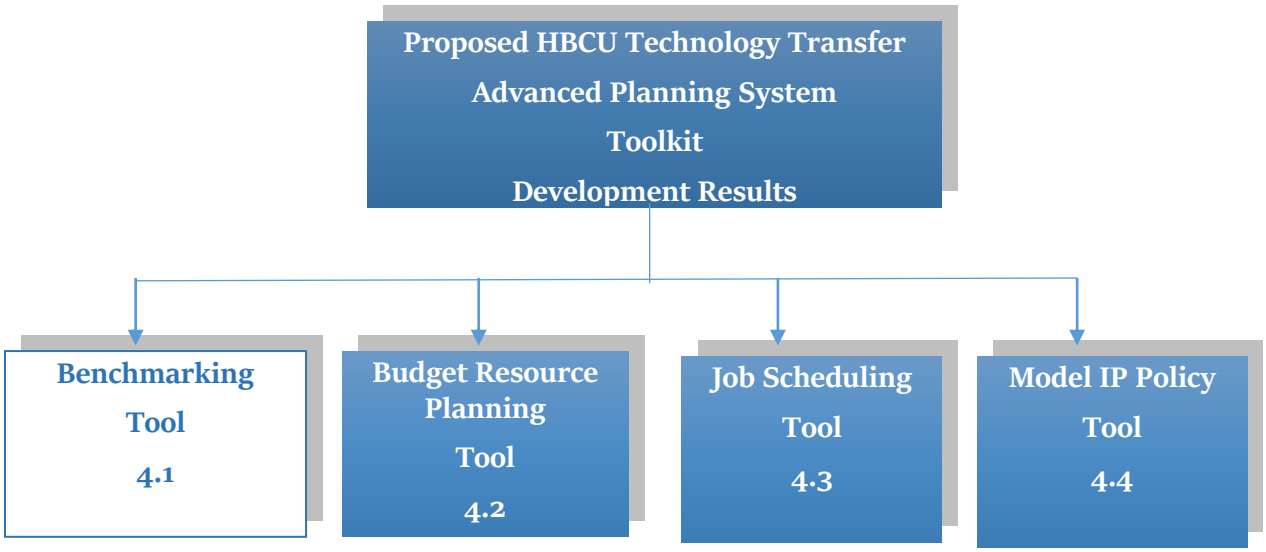


Figure 33. Benchmarking Tool Development Results § 4.1

4.1.1 HBCU Research and Technology Transfer Program Features

First, the HBCUs with PhD doctoral programs were selected from the White House Initiative on HBCUs listing of 101 accredited HBCUs. The Carnegie classification database was used to a sample of 24 HBCUs with PhD doctoral programs. The list of HBCUs is shown in Table 9 along with their tech transfer and research program features.

The NSF database was searched for the sponsored research expenditures at each of these 24 HBCUs. Further, a search of each of their web pages revealed detailed information about their following research and tech transfer practices:

- Tenure & Promotion (TNP) & IP policies accessible online;
- Patents counts toward TNP;
- Start-up or Spin off Equity policy;
- Royalty sharing;
- Venture capital fund;
- Release time, Sabbatical or other relief for research;
- Stand-alone OSP;
- Stand-alone TTO;
- IP Committee;
- Research in Vision statement; and
- Research in Mission statement.

The data that was collected was coded as follows:

- NA = not accessible;
- NF = not found;
- NM = not mentioned; and
- Y = YES (when found).

Table 9. HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[3]	Research in Vision?	Research in Mission?
AL A&M	5,020	AL	Faculty Handbook, Graduate Catalog Food Science, and the University's Website Search Tool[4]	NF	NM	≤$100k net income, 50% to inventor, 25% college, 25% university; if >$500k, 40% to inventor, 25% to the inventors' Department / School and 35% to University	NF	Y Up to 25%	Y	Y[5]	Y	Total: 32,907 Federal: 22,428 Industry: 414	Y	Y

[3] Source: (NSF, 2014a).

[4] Sources: (AAMU, 2011, 2014, 2015).

[5] Research, Innovation, Science and Engineering (RISE) Foundation.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
AL State	6,075	AL	Faculty Handbook, Intellectual Property Policy, and the University's Website Search Tool[7]	NF	NM	50% net to inventor	NF	NF	Y	NF	Y	Total: 2,236 Federal: 2,236 Industry: 0	Y	Y
Bowie State	5,561	MD	University Policies, UMD system IP Policy & the University's Website Search Tool[8]	NF	Y	50% net to inventor; 50% to university (85% to research in inventor's department ; 15% to other depts.)	Y[9]	NF	Y	NF	Y	Total: 1,761 Federal: 1,761 Industry: 0	Y	Y

[6] Source: (NSF, 2014a).
[7] Sources: (ALASU; ALASU, 2009a, 2009b).
[8] Sources: (Bowie, 1998, 2002, 2016a, 2016b; UMD, 2005).
[9] The University System of Maryland has a $25M Early Stage Investment Fund.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Clark Atlanta	3,458	GA	Faculty handbook includes intellectual property policy, SACs compliance report, and the university's website search tool[10]	NF	Y	25% to inventor, 75% to university (15% to school and 5% to department)	NF	Y	Y	Y	Y	Total: 9,192 Federal: 7,241 Industry: 62	Y	Y
Delaware State	4,356	DE	University Procedure, TNP Policy and the university's website search tool[11]	NF	NM	The Provost decides the allocation of proceeds.	Y	Y	Y	Y	NF[12]	Total: 17,679 Federal: 12,464 Industry: 261	Y[13]	Y

[10] Sources: (Brown, 2009; CAU, 2013a, 2013b).
[11] Sources: (DESU, 2004, 2016).
[12] Delaware State University's first technology transfer was in 2011 (DESU, 2011).
[13] Delaware State University has an interesting objective in their 5-year strategic plan to increase patent generation by 50%.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Fayetteville State	6,179	NC	TNP policy, UNC Equity Acquisition Policy, UNC Patent and Copyright Policies, Copyright Use and Ownership policy, and the university's website search tool[14]	NF	Y	The inventor shall receive not less than 15% of the gross per the UNC patent policy.	Y[15]	Y	Y	Y	Y	Total: 14,732 Federal: 10,186 Industry: 161	NF	Y

[14] Sources: (FSU, 2008, 2009, 2016; UNC, 2001, 2005).
[15] There is an IMAF and Rural Venture Fund (FSU, 2008).

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
FAMU	10,743	FL	TNP criteria & IP Procedures[16]	NF[17]	NM	40% net to inventor, 60% to university, 20% to inventor's college or department	NF[18]	Y	Y	Y	Y	Total: 46,367 Federal: 36,570 Industry: 719	Y	Y
Grambling	5,071	LA	Faculty handbook includes IP Policy[19]	NF[20]	NM	NM	NF	Y	NF	NF	Y	Total: 1,469 Federal: 1,065 Industry: 0	Y	NF

[16] Sources: (FAMU, 2005, 2016a, 2016b, 2016c).
[17] FAMU's tenure criteria includes research or other scholarly activity or other creative activities including being sought as a consultant in the faculty member's research area (FAMU).
[18] Although no venture fund was found for faculty start-ups, in 2015 Florida State University and FAMU's colleges of engineering merged. There is a student new product competition, Genevia Student Business Grant, and Dupont Minority Student Venture Fund (FLSU, 2013; Larrabee, 2015).
[19] Sources: (Grambling, 2002, 2011, 2014).
[20] Note that Grambling's policy to not count patents toward tenure or promotion conflicts with the Louisiana Board's expectation for inventor IP development as evidence of productivity which is noted in the faculty handbook (Grambling, 2002). There's a misalignment.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Hampton	4,622	VA	IP Policy, Tenure Dossier Checklist, Preparing an Effective Dossier & Academic Programs, Processes and Responsibilities [21]	NF	Y	Y Amount not noted; part to inventor and part to university general fund	NF	NF	Y	NF[22]	NF	Total: 11,169 Federal: 11,153 Industry: 0	Y	Y
Howard	10,297	DC	Faculty handbook includes IP Policy[23]	NF	NM	NM	NF	Y Sabbaticals for research	Y	Y	Y	Total 40,771 Federal: 32,663 Industry: 1,087	Y	Y

[21] Sources: (Hampton, 1999, 2016a, 2016b; McGhee, 2012; Murphy, 2009)
[22] Tech transfer is the Vice President for Research's responsibility at Hampton University.
[23] Source: (Howard, 1993)

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Jackson State	9,134	MS	Faculty handbook includes IP Policy by ref; IP policy not accessible online; Teaching Load and Release time policy[24]	NF	NA	NF	NF	Y	Y	Y	NF	Total: 26,609 Federal: 21,677 Industry: 0	Y	Y
Meharry Medical College	801	TN	IP Policy & Policy on Guidelines for Promotion and Tenure[25]	NF	Y	50% to inventor; 50% to College	NF	Y[26]	Y	NF	Y	Total: 18,997 Federal: 17,754 Industry: 54	Y	Y

[24] Sources: (JSUMS, 1991, 2011, 2016).
[25] Sources: (Hildreth, 2015; Meharry, 2009, 2016a, 2016b).
[26] Release time was mentioned in the 2009-2014 Strategic Plan related to a Faculty Development Program ("M-PACT Meharry's Plan for Action 2009-2014 The Strategic Plan for Years 2010-2014," 2010).

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Morehouse Medical School	372	GA	Faculty handbook; Faculty Development Program; and IP policies[27]	NF	NM	60% net to inventor; 40% to institution	NF	Y[28]	Y	Y	Y	Total: 41,858 Federal: 33,020 Industry: 511	NM	Y

[27] Sources: (MSM, 2008, 2010, 2011, 2016; Rust, 2006).

[28] As with Meharry Medicine, a Faculty Development Program for research and writing is related to the release time at the Morehouse School of Medicine (Rust, 2006).

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Morgan State	7,546	MD	Faculty handbook, Legislative Testimony FY 2017 Operating Budget & Patents policy[29]	NF[30]	NM	$5000 net to inventor and then 50% to inventor; 85% of university share goes to inventor's department up to $100,000 and remainder goes to research and patenting	NF	Y	Y	Y	Y	Total: 15,720 Federal: 14,144 Industry: 226	Y	Y

[29] Sources: (Morgan, 1996, 2005, 2009, 2016; Wilson, 2016).

[30] At Morgan State University, faculty members are to satisfy the tenue and promotion criteria for promotion and tenure set by the departments, colleges, schools, and the University. So, the criteria vary between department, college and school.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
NC A&T	10,561	NC	Faculty handbook & Intellectual Property policy[31]	NF	NM	Inventors shall get no less than 15% per UNC System patent policy; the inventors get 50% of the first $500,000 of net revenue and 35% of cumulative net revenue thereafter	NF	Y	Y	Y	Y	Total: 35,047 Federal: 23,373 Industry: 7	Y	Y

[31] Sources: (NCAT; NCAT, 2009, 2014, 2016)

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Norfolk State	6,728	VA	Faculty handbook includes IP Policy by reference; IP Policy and Procedures; and Faculty Development Support Guidelines[32]	Y[33]	NM	50% to inventors, 50% to university depts. and centers	NF	Y	Y	NF[34]	Y	Total: 6,936 Federal: 6,492 Industry: 0	Y	Y

[32] Sources: (Mattix, 2000; NSU, 2000, 2015, 2016).

[33] Patents are defined as Creative Works in the Faculty Handbook and faculty get credit for creative work and activity toward promotion and tenure.

[34] The university uses an external agency specializing in patent review such as *Research Corporation*, *University Patents or Innovative Technology* to review their employee's inventions.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Prairie View	8,283	TX	Faculty handbook & IP Policy; Texas A&M University System Intellectual Property Management and Commercial-ization; Faculty Workload Policy Quick Reference; College of Engineering and Architecture Tenure and Promotion Manual[35]	NF	Y	42.5% net revenues to inventors, 39.5% to the member supporting the research leading to the disclosures, 18% to the TTO	NF	Y	Y	NF[36]	NF[37]	Total: 12,292 Federal: 8,278 Industry: 0	NF[38]	Y

[35] Sources: (PrairieView, 2007, 2008, 2009, 2015, 2016; TexasA&M, 2012; G. C. Wright, 2006).

[36] In 2011, Prairie View University initiated a drive to enhance its research production and innovation. Prairie View's tech transfer is handled by Texas A&M University's Office of Tech Commercialization.

[37] There is mention of a "System" patent committee since Prairie Views' tech transfer is handled by Texas A&M.

[38] Each unit underwent a strategic planning effort to develop missions and visions at the unit level. No vision for the university overall was found.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
SC State	3,463	SC	Faculty handbook (need faculty password to access); Handbook for sponsored research; Promotion application[39]	NF	NM	NF	NF	Y	Y	NF[40]	NF	Total: 13,147 Federal: 10,306 Industry: 10	NF	Y
Southern Univ Baton Rouge	6,777	LA	Faculty handbook and IP Policy[41]	NF	NM	40% net to inventors, 60% to originating institute for R&D	NF	NF	Y	NF	Y	Total: 4,812 Federal: 3,850 Industry: 2	Y	Y

[39] Sources: (SCSU, 2007, 2013, 2015, 2016).
[40] SC State University's Office of Sponsored Programs uses approved tech transfer agents.
[41] Sources: (PrairieView, 2009; Southern; Southern, 2005, 2007, 2009, 2010, 2014).

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
TN State	8,883	TN	Faculty handbook; IP policy; and Release Time Justification Form[42]	Y	Y	≤ $100k, 50% to inventor, 10% to division, 40% to university; >$100k, 40% to inventor, 15% to division, 45% to university	NF	Y	Y	Y	NF	Total: 20,068 Federal: 12,016 Industry: 321	NM	Y

[42] Sources: (TNState, 2014a, 2014b, 2014c, 2016a, 2016b).

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
TX Southern	8,703	TX	Faculty manual includes patent policy[43]	Y[44]	Y	Schedule that ranges from ≤ $100k, 50% to inventors, to > $300k, then 25% to inventors	NF	NF[45]	Y	Y	Y	Total: 6,038 Federal: 3,512 Industry: 83	Y	NM

[43] Sources: (TxSouthern; TxSouthern, 2009, 2014, 2015a, 2015b).
[44] TX Southern University's TNP policy states that "the acquisition of patents or other forms of official recognition for inventions" is criteria for promotion (TxSouthern, 2014).
[45] A Dean's Council meeting and College of Science and Engineering Technology (CSET) Strategic Plan mentions the desire for release time for research (TxSouthern, 2009).

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Tuskegee University	3,118	AL	IP policy in Faculty handbook; IP Policy and Guidelines; Detailed Guide to Research and Sponsored Programs[46]	Y[47]	NM	50% to inventor; 50% to university	NF	Y	Y	N	Y	Total: 24,945 Federal: 14,145 Industry: 404	Y	Y

[46] Sources: (TuskegeeUniversity, 2005, 2013, 2015, 2016a, 2016b).

[47] Tuskegee University's TNP policy states that "patents and royalties in those disciplines that reflect excellent scholarly work but is not immediately publishable" counts towards tenure.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
University of Maryland Eastern Shore	4,220	MD	Faculty handbook & UMD patent policy[48]	Y	Y	UMD System gives 10% to inventors, 30% to their TTO, 60% university expenses from the initial receipt of income, then of net 50% to inventors, 50% to university (85% Dept, 15% patenting promotion)	Y[49]	Y	Y	NF[50]	Y	Total: 8,982 Federal: 8,902 Industry: 0	Y[51]	Y

[48] Sources: (UMES, 2005, 2016a, 2016b, 2016c).
[49] The UMD System has a MTech Venture Fund.
[50] Tech transfer at the University of Maryland Eastern Shore is managed by the University of Maryland College Park's Office of Technology Liaison.
[51] Their 2004 Strategic Plan for 2020 states that the University of MD Eastern Shore desires to become Carnegie Research Intensive.

Table 9. Continued. HBCU Research and Tech Transfer Program Features
NA = not accessible, NF = not found, NM = not mentioned, Y = YES

HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital?	Release time, Sabbatical or other relief for research?	Stand-alone OSP?	Stand-alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[6] ?	Research in Vision?	Research in Mission?
Virginia State	5,763	VA	TNP policy; IP Policies; Tenure criteria[52]	NF	NM	1st $1000 to author and then ½ to author and ½ to university	NF	Y	Y	NF	NF	Total: 8,374 Federal: 5,424 Industry: 0	Y	Y

[52] Sources: (VSU, 2004, 2007, 2013, 2015).

An internet search was conducted to find reports of HBCU licensing revenue generation amounts. Only two (2) reports of HBCU licensing revenues were found:

- Florida A&M University $7,500 (2013) (FAMU, 2015); and
- Prairie View University $8.5 Million (2010) (Case, 2013).

However, some of the HBCUs are striving to create entrepreneurial cultures. Examples are faculty and student entrepreneurship programs at Howard University and Prairie View.

4.1.2 Non-HBCU Research and Technology Transfer Program Features

Using the AUTM STATT database, non-HBCUs in the 17 HBCU geographic locations (based on states) for years 2010-2014 were selected. In applying the social comparison theory portion of the theoretical framework, he goal was to find non-HBCUs: (1) located in the same states as the selected HBCUs; and (2) schools within licensing revenues in the lowest quartile of the AUTM licensing survey data for 2010-2014.

Table 10 lists nine (9) non-HBCUs, including their student enrollment, that were identified as having gross licensing revenue in the lower quartile at any given year between 2010-2014 as reported in the AUTM Annual Licensing Surveys for those years. These 9 non-HBCUs have student enrollment which closely match's student enrollment range of 372 – 10,743 students.

Table 11 provides the following descriptive statistics for the select non-HBCUs retrieved from the AUTM STATT database:

- **Lic FTEs** – No. of Full Time Equivalent Licensing Staff in the TTO;
- **Oth FTEs** - No. of Full Time Equivalent Other Staff in the TTO;
- **Tot Res Exp** – Total Research Expenditures;

- **Fed Res Exp** – Federal funded Research Expenditures;
- **Ind Res Exp** – Industry funded Research Expenditures;
- **Tot Lic Opt Exec** – Total Licenses and Option Agreements Executed;
- **Inv Dis** – No. of Invention Disclosures;
- **Tot Pat App Filed** – No. of Patent Applications Filed;
- **St Ups Formed –** No. of Start Up Businesses formed with the TTO's assistance; and
- **Gross Licensing Income.**

Table 10. Select Non-HBCUs for HBCU Comparisons

	Select Non-HBCUs Targeted for Comparisons	Student Enrollment
[1]	Baylor College of Medicine	1,584
[2]	Georgia Regents University	7,988
[3]	Medical Univ. of South Carolina	2,898
[4]	Rice University	6,621
[5]	University of Alabama in Huntsville	7,348
[6]	University of North Texas Health Science Center	2,243
[7]	Wake Forest University	7,788
[8]	Eastern Virginia Medical School	1,049
[9]	Louisiana Tech University	11,225

Table 11. Non-HBCUs' Tech Transfer Program Data for HBCUs' Benchmarks

	Min	Med	Mean	Max	Var
Gross Licensing Income	$15,000	$397,596	$5,100,505	$85,991,743	2.E+14
Student Enrollment	1049	4759.5	4977	11225	1.E+07
St Ups Formed	0	2	2	8	3.68
Tot Pat App Filed	5	32	40	180	1437.83
Inv Dis	7	42.5	58	167	1918.12
Leg Fees	$42,759	$510,052	$771,432	$4,018,842	9.E+11
Tot Lic Opt Exec	1	7.5	13	57	205.45
Ind Res Exp	$0	$7,725,314	$11,937,386	$55,391,086	2.E+14
Fed Res Exp	$0	$74,641,005	$102,986,425	$352,485,200	8.E+15
Tot Res Exp	$26,020,000	$96,486,743	$136,709,898	$403,351,000	1.E+16
Oth FTEs	0.5	2.25	2.42	7	2.60
Lic FTEs	1	2	2.82	7	4.07

To illustrate how the HBCUs and select non-HBCUs compare, Figure 34 provides a comparison of the FY 2014 non-HBCUs' and HBCUs' R&D expenditures. The non-HBCUs reportedly have 10 times more total R&D funding than the HBCUs. The non-HBCUs have seven (7) times more federal R&D funding; and 200 times more industry funding than the HBCUs.

Although the 24 Doctoral Research HBCUs are gravely behind the non-HBCUs in research expenditures, they have steadily sustained and slightly increased their research over time as shown in Figures 35 and 36 below. Following Figures 35 and 36, Table 12 provides detailed information about the select non-HBCUs' tech transfer Policies.

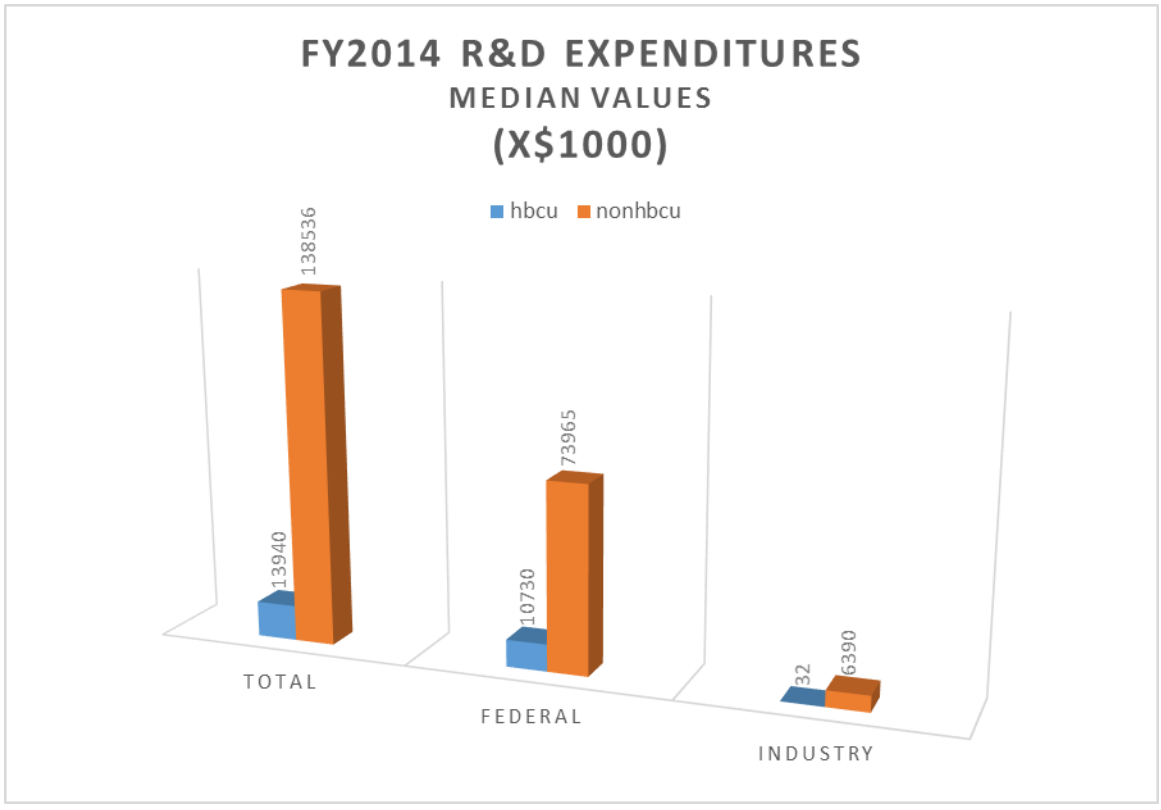


Figure 34. HBCU and non-HBCU Research Expenditure Comparison, FY2014
Source: (NSF, 2014a, 2014b).

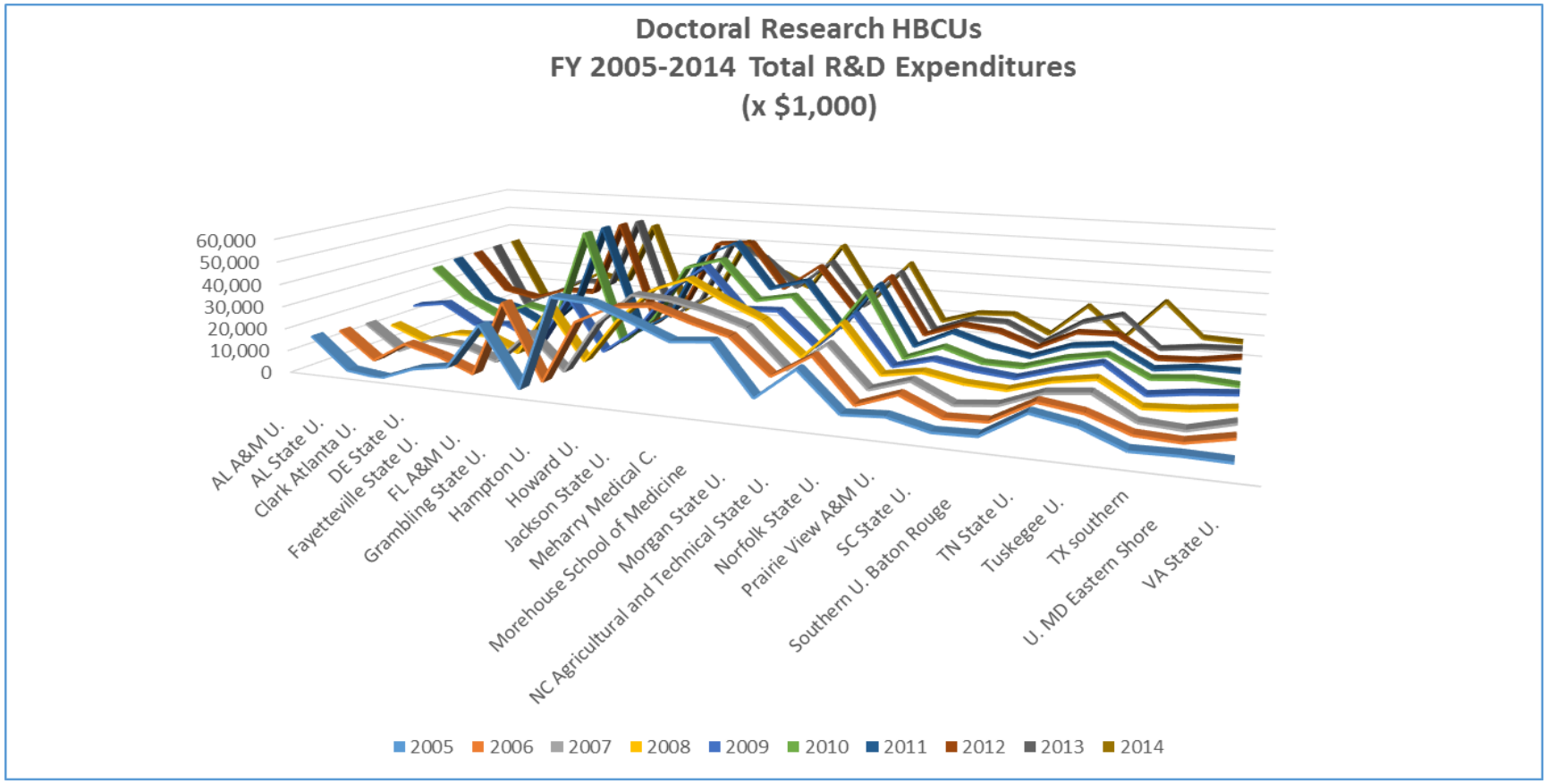


Figure 35. Doctoral Research HBCUs FY 2005-2014 Total R&D Expenditures

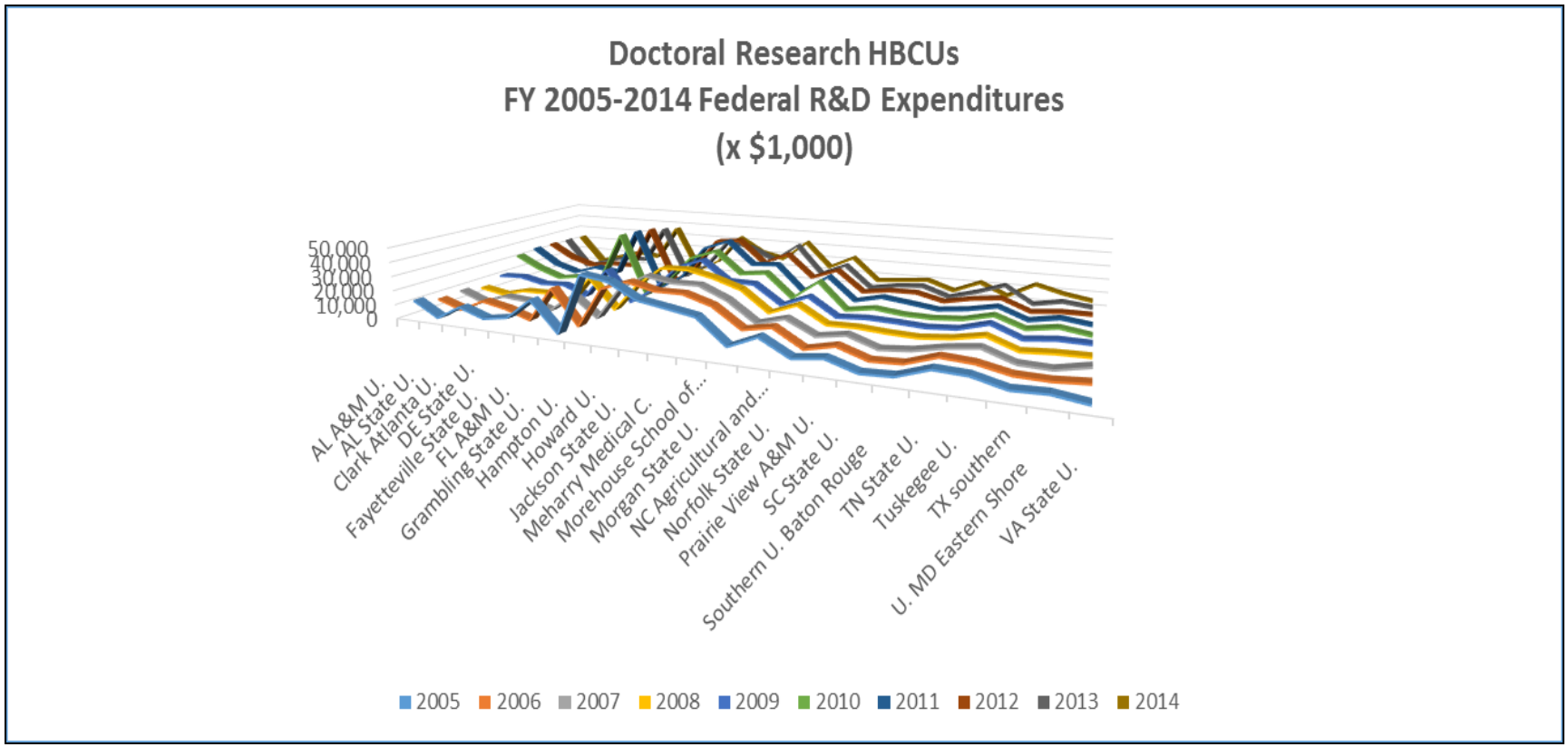


Figure 36. Doctoral Research HBCUs FY 2005-2014 Federal R&D Expenditures

Table 12. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[53] ?	Research in Vision?	Research in Mission?
Baylor College of Medicine	1,584	TX	Faculty Handbook (require faculty login) & Policy on Patents and IP[54]	NA	Y	40% to inventors, 30% to inventors' department (s), 30% to general fund	NF	Y[55]	Y	Y	NF	Total: 496,314 Federal: 264,641 Industry: 15,547	Y	Y

[53] Source: (NSF, 2014a).

[54] Sources: (Baylor, 2016a; "Baylor College of Medicine Licensing Revenue," 2016).

[55] Baylor College of Medicine's Faculty Development Fellows get 10% release time (Baylor, 2016b).

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
Georgia Regents (now Augusta University) [57]	7,988	GA	IP Guidelines; and Guidelines for Faculty Promotion and Tenure[58]	N	NM	35% to inventors, 35% to university, 10% to department (s), 20% to GRURI, the GA Health Sciences Research Institute	NF	Y[59]	Y	Y	Y	Total: 64,118 Federal: 47,771 Industry: 2,915	Y	Y

[56] Source: (NSF, 2014a).

[57] In 2012, Augusta State University and the Georgia Health Sciences universities were consolidated by the Georgia Board of Regents into Georgia Regents University. The university changed its name Augusta University in 2015. Sources: (Crawford, 2012; Wynn, 2015).

[58] Sources: (GARegents, 2013, 2016a, 2016b).

[59] Like Baylor Medicine, Georgia Regents has a Faculty Development Fellowship (GARegents).

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
Med Univ. of SC	2,898	SC	Faculty Handbook includes IP Policies; and IP Policy in Faculty Senate Handbook[60]	NF	Y	≤ $10k, inventors get 100% net with 15% of gross to university for patenting expenses; >$10k, 40% to inventors, 10% to inventors' department, 15% to lab, 10% to angel fund and 20% to university	Y[61]	Y[62]	Y	Y	Y	Total: 242,594 Federal: 118,649 Industry: 16,103	NM	Y

[60] Sources: (MUSC, 2011, 2016b)

[61] The Medical University of South Carolina has an Angel Fund (MUSC, 2016a).

[62] The Medical University of South Carolina has a sabbatical for faculty development (MUSC, 2011).

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
Rice University	6,621	TX	Faculty handbook & Patent and Software Policies[63]	NF	Y	37.5% of net to inventors, 18.5% to graduate education, 14% to dept, 30% to univ	NF[64]	NF	Y	Y	Y	Total: 138,536 Federal: 73,965 Industry: 6,390	Y	Y

[63] Sources: (Rice; Rice, 1999, 2005, 2014b).

[64] Although no venture fund was found, there is a Rice Alliance for Technology and Entrepreneurship is a biz plan competition which has given away $1.3M in prizes (Rice, 2014a).

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
University of AL Huntsville	7,348	AL	Faculty Handbook and Patent Policy[65]	NM	NM	≤ $50k net, 70% to inventors, 20% to inventors' unit, 10% to research fund; if > $50k, 40% to inventors, 40% to inventors' unit and 20% to research fund	Y[66]	Y A re-distribution of non – research work is allowed if the faculty members can charge to a research grant, contract or center	Y	Y	Y[67]	Total: 89,325 Federal: 75,343 Industry: 1,441	Y	Y

[65] Sources: (UALHuntsville, 2014a, 2014b, 2016b, 2016c).

[66] The University of AL Huntsville has a Charger Innovation Fund (UALHuntsville, 2016a).

[67] The President of the University of AL Huntsville is required to appoint a Patent Officer "or" Patent Committee.

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
University of No Texas Health Science Center	2,243	TX	Academic Affairs' Faculty Promotion and Tenure Policies; and IP Policy[68]	Y[69]	Y	50% to inventors, 50% to university; and a different schematic if equity shares are sold	Y[70]	Y[71]	Y	Y	Y	Total: 47,002 Federal: 21,943 Industry: 2,981	NM	NM

[68] Sources: (UNTHSC, 2006, 2010, 2015a, 2016a, 2016b).

[69] The criteria for Tenure and Promotion at the University of North Texas Health Science Center varies with each school. Their School of Public Health allows faculty's inventions and patents to count toward tenure and promotion (UNTHSC, 2015b).

[70] The University of North Texas System which has a New Venture Fund and competitors must include at least one student; and The University of North Texas Health Science Center is in this system (UNTSystem, 2010).

[71] At the University of North Texas Health Science Center, release time is at the Dean's or Chair's discretion and requires "exceptional productivity" in return.

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
Wake Forest	7,788	NC	Faculty Handbook & Invention and Patent Policy[72]	NF	Y	35% of gross to inventors and 65% to university; and after the recovery of university's expenses, 35% net to inventors, 10% to inventors' dept & 55% to university; if > $1M, 35% to inventors, 65% to university	NF[73]	Y Varies per academic unit & per Dean's instructions	Y	Y	NF	Total: 176,380 Federal: 153,069 Industry: 7,794	N	Y

[72] Sources: (WakeForest; WakeForest, 2015, 2016b).

[73] There is evidence that Wake Forest University is currently fundraising and trying to build a Venture Capital Fund for Renewable Energy and Sustainable Technology in its Center for Energy and Environmental Sustainability (CEES) (WakeForest, 2016a).

Table 12. Continued. Non-HBCU Research and Tech Transfer Program Features

NA = not accessible, NF = not found, NM = not mentioned, Y = YES

Non-HBCU	Student enrollment	State	Tenure & Promotion (TNP) & IP policies accessible online?	Patents count toward TNP?	Start-up or Spin off Equity policy?	Royalty sharing?	Venture capital fund?	Release time, Sabbatical or other relief for research?	Stand- alone OSP?	Stand- alone TTO?	IP Committee?	FY 2014 Research expenditures (x $1,000)[56] ?	Research in Vision?	Research in Mission?
Eastern VA Med (EVMS)	1,049	VA	Faculty Handbook & IP Policy[74]	NF	NM	1/3 net to inventors, 1/3 to inventors' depts., 1/3 to university	NF[75]	Y	Y	Y	NF	Total: 43,917 Federal: 28,532 Industry: 1,886	NM	Y
Louisiana Tech	11,225	LA	IP Policy[76]	NF	NM	40% to inventors, 15% to inventors' college, and 45% to university	NF	Y	Y	Y	Y	Total: 22,942 Federal: 7,742 Industry: 803	Y	Y

[74] Sources: (EVMS, 2011, 2016a, 2016b).

[75] Although no venture capital fund was found for faculty start-ups, EVMS does have a Research and Scholarly Activity Incentive Fund whereby a department's faculty member gets 25% of facilities and administrative (F&A) recovery from a grant that pays for a facility or administration covering 20% of salary; and can get a bonus up to 30%.

[76] Sources: (LATECH; LATECH, 2005, 2016).

4.1.3 Comparison of HBCU and non-HBCU Program Features

Table 13a. provides a summary of Tables 11 and 12; and thus, a comparison between the HBCUs and non-HBCUs regarding the current state of their research and tech transfer program features. Table 13a. illustrates that the HBCUs have several tech-transfer programmatic features in place.

Table 13a. Summarized Comparison of HBCUs and non-HBCUs' Tech Transfer Program Features

	Patents count toward TNP %	Equity %	Royalty Sharing %	VC Fund %	Release time for Research %	Stand-alone OSP %	Stand-alone TTO %	IPC %	Research in Vision %	Research in Mission %
HBCUs	20.8	37.5	75	20.8	75	87.5	50	66.7	79.2	91.7
Non - HBCUs	11.1	55.6	100	33.3	88.9	100	100	55.6	55.6	88.9
Δ (HBCUs % - Non HBCUs %) HBCUs' areas of weakness	+9.7	**-18.1**	**-25**	**-12.5**	**-13.9**	**-12.5**	**-50**	+11.1	+23.6	+2.8

Consistent with the 2009 NAE/ NRC Partnerships for Emerging Research Institutions report which stated that HBCUs are behind in having an entrepreneurial culture that rewards faculty involvement in tech transfer activities, the HBCUs' primary area of weakness is in not having stand-alone TTOs to support their tech transfer activities ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009). Although, Delaware State University, Fayetteville State, Morgan State, TN State and TX Southern were counted as having stand-alone TTOs, they share this function within their Offices of Sponsored Programs. They are credited with providing

tech transfer services and support to their faculty. This is a positive advance toward forging an entrepreneurial campus culture that rewards faculty for participating in tech transfer activities. Table 13b. provides a comparison of TTO staffing between the HBCUs and the non-HBCU comparison schools. It shows that the non-HBCUs have more TTO staff than the doctoral HBCUs.

Also, 12.5% of the HBCUs do not have visible stand-alone Offices of Sponsored Programs. There are noticeable similarities between the HBCUs and non-HBCUs which is in alignment with the social comparison theory portion of the theoretical framework. As per the social comparison theory, similarity may take different forms and should be looked for on a broad range of related attributes (Hogg, 2000) as was done here. With respect to social comparisons, the evaluations of group abilities are made when groups compare themselves to groups that are similar to them on relevant dimensions. This builds pressure for uniformity. The comparisons are made with groups that are marginally and slightly better (Forsyth, 2000).

In addition to the tech transfer data provided in Tables 11-13b, using the NRC Data-Based Assessment of Research Doctorate Programs in the United States for 2005-2006, data was collected for the selected non-HBCUs which participated in the NRC assessment and is provided in Table 14. The assessment serves to help universities improve their Doctoral program quality. This database was used to collect the following faculty quality measures:

- Number of publications per allocated faculty member,
- number of citations per publication,
- % faculty with research grants,
- % faculty with honors and awards,
- % non-Asian minorities,
- % women,
- % faculty engaged in inter-disciplinary research,

- faculty size per program,
- % assistant professors, and
- % tenured professors.

Table 13b. Comparison of TTO Staffing between the Doctoral HBCUs and non-HBCUs

HBCUs	Lic FTEs**	Other FTEs		non-HBCUs	LicFTES***	Other FTEs
AAMU	2	0		Baylor College of Med	6	3
Clark Atl	1	0		Georgia Regents	3	2
DESU*	1	0		MUSC	3	6
Fayetteville State*	1	1		Rice	5	7
FAMU	1	2		Univ AL Huntsville	1	1
Howard	1	0		Univ No TX Health Sci	1.25	1
J State	1	0		Wake Forest	4	3.5
Morehse Schl Med	1	0		EVMS	1	1
Morgan St	2	0		Louisiana Tech	1	0.5
NCAT	2	0				
TN State*	1	0				
TX Southern*	3	0				
Median values	**1**	**0**			**3**	**2**

*Tech transfer services are provided in their Offices of Sponsored Programs.
**Licensing and Other FTEs were found using a website search of the HBCUs.
***Licensing and Other FTEs were found using the AUTM STATT database for FY 2014.

Baylor College of Medicine, Rice University, Wake Forest, University of AL Huntsville, and the University of North Texas Health Sciences participated in the NRC survey. The study data is at the program level. Note that the only HBCU that participated in the NRC assessment was Howard University; and data for the University of MD Eastern Shore was included in the University of MD Baltimore's statistics.

4.1.4 Proposed Benchmarking Tool

Based on the non-HBCU data information, the proposed benchmarking tool for HBCUs was refined and is depicted in Figure 37 to include median values of tech transfer program characteristics that HBCUs can evaluate themselves against. These mean values are noted in red. For the non-HBCU stock of patents, refer to Table 15. The stock of patents comes from the USPTO Patent database.

4.2 HBCU Tech Transfer Budget Resource Planning Tool Development Results

As noted in Figure 38, this section provides the results of the budget resource planning tool experimentation. One (1) experiment was conducted. The experiment uses linear programming model is a decision support optimization tool commonly used in supply chain management. The motivation for these model formulations is explained in the Research Approach section of this study located in the Research Methods Chapter III, part 3.2.2.

Using Microsoft Excel Solver's Simplex LP optimization tool, the optimal number of inventions to license to each customer is computed with an objective function that serves to minimize costs subject to the following constraints:

S_i, Supplies are patented invention licensing deals

D_j, Customer demands

C_{ij}, Cost that Suppliers i incur when licensing the patented inventions to customers j

x_{ij}, Amount of patented invention licensing deals to be licensed between Supplier i and Customers j

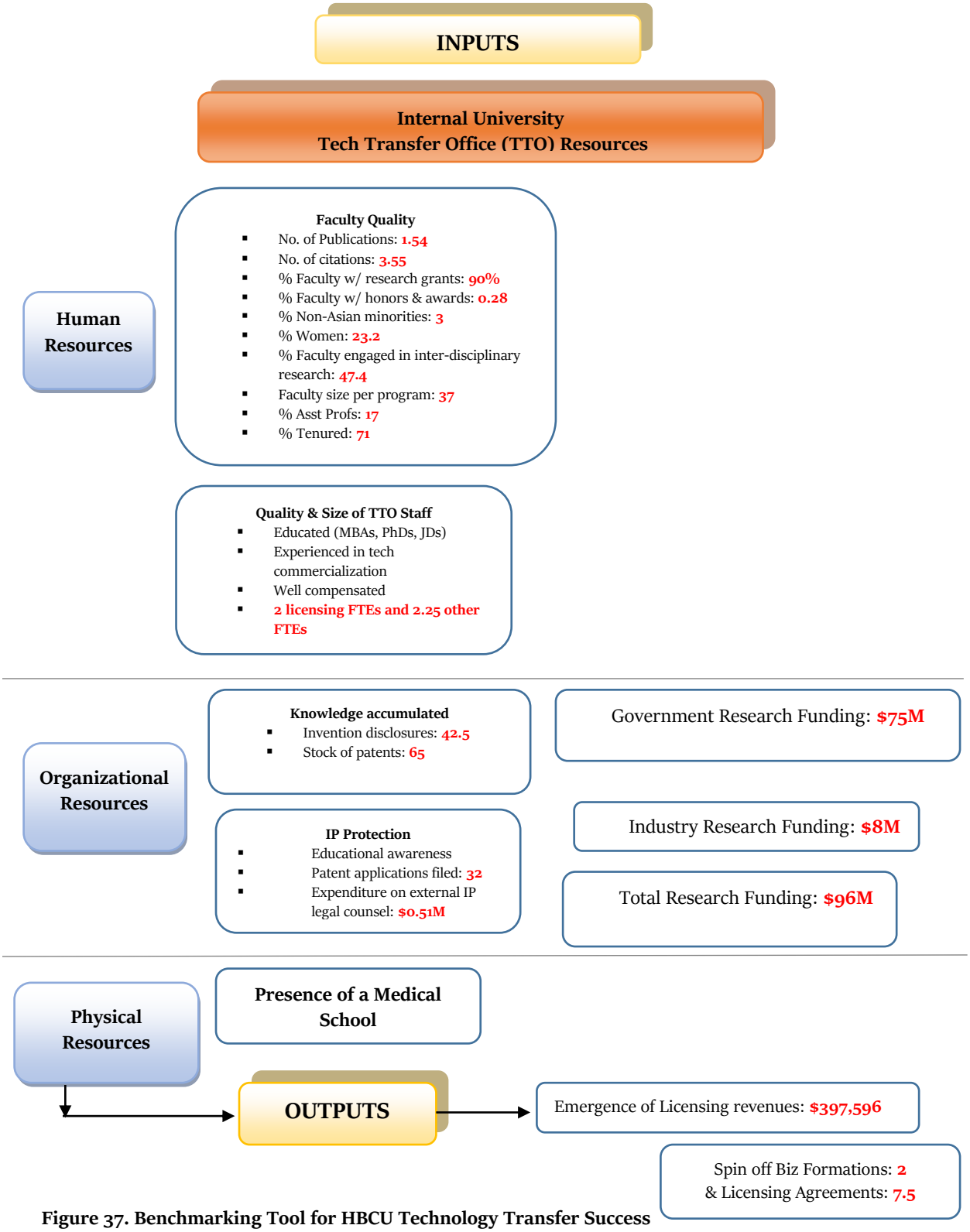


Figure 37. Benchmarking Tool for HBCU Technology Transfer Success

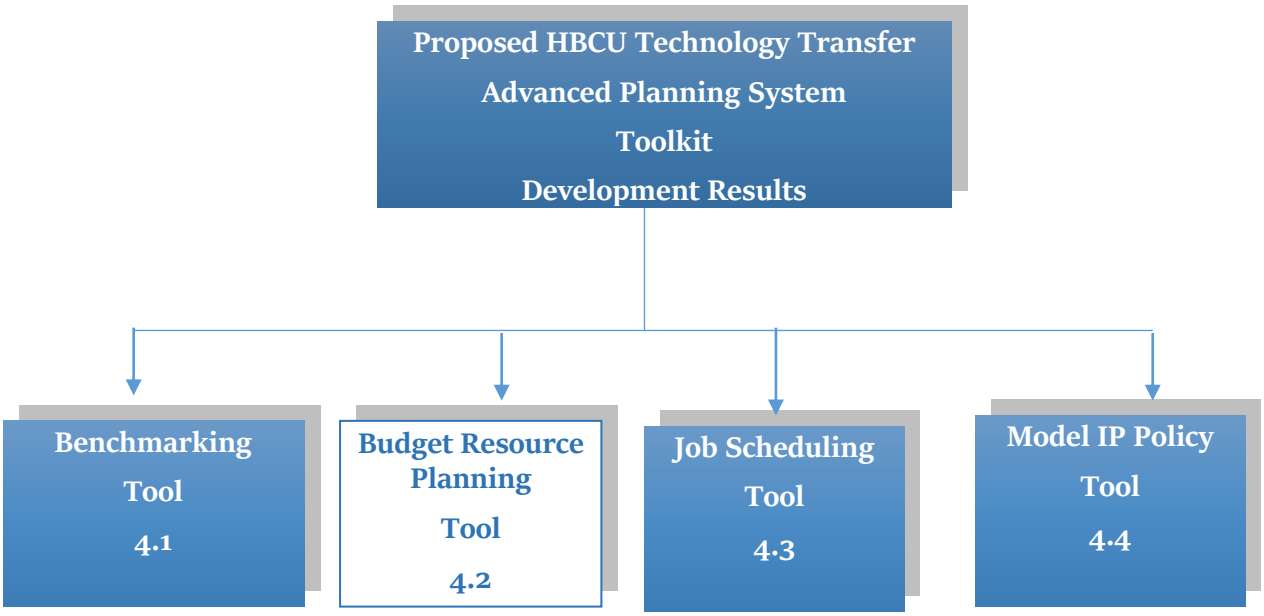


Figure 38. Budget Resource Planning Tools Development Results § 4.2

Table 15. Non-HBCUs' Licensing Cost and Supply Capacity Data

					Supplier Costs (Cij)			
	Non-HBCUs	LEGAL FEES	Size TTO Staff	Total Licensing Deals	Annual Salaries	TTO Staff Labor Expense	Total Expense	No. of Inventions
		(a)	No. FTES			(b)	(a + b)	Supply Capacity
								(Ci)
2011	Baylor	$316,000	5	47	102330	4809510	$5,125,510	418
2012	Baylor	$575,000	7	36	102330	3683880	$4,258,880	
2013	Baylor	$538,848	6	38	102330	3888540	$4,427,388	
2014	Baylor	$394,215	6	57	102330	5832810	$6,227,025	
2012	Georgia Regents	$501,036	1	4	98990	395960	$896,996	8
2013	Georgia Regents	$615,130	3	6	98990	593940	$1,209,070	
2014	Georgia Regents	$439,759	3	11	98990	1088890	$1,528,649	
2010	Medical Univ. of SC	$577,406	1.25	7	74550	521850	$1,099,256	35

Table 15. Continued. Non-HBCUs' Licensing Cost and Supply Capacity Data

					Supplier Costs (Cij)			
	Non-HBCUs	LEGAL FEES	Size TTO Staff	Total Licensing Deals	Annual Salaries	TTO Staff Labor Expense	Total Expense	No. of Inventions
		(a)	No. FTES			(b)	(a + b)	Supply Capacity (Ci)
2011	Medical Univ. of SC	$505,968	1.25	11	74550	820050	$1,326,018	
2012	Medical Univ. of SC	$457,878	2.55	6	74550	447300	$905,178	
2013	Medical Univ. of SC	$642,224	2.5	11	74550	820050	$1,462,274	
2014	Medical Univ. of SC	$514,135	3	13	74550	969150	$1,483,285	
2010	Wake Forest Univ.	$4,018,842	4	14	85650	1199100	$5,217,942	284
2011	Wake Forest Univ.	$3,347,909	5	24	85650	2055600	$5,403,509	
2012	Wake Forest Univ.	Not reported	5	23	85650	1969950	$1,969,950	
2013	Wake Forest Univ.	Not reported	5	25	85650	2141250	$2,141,250	
2010	Univ. of No Texas	$112,482	1.5	4	102330	409320	$521,802	33
2011	Univ. of No Texas	$72,084	1	6	102330	613980	$686,064	
2012	Univ. of No Texas	$88,823	1	4	102330	409320	$498,143	
2013	Univ. of No Texas	$88,325	1	7	102330	716310	$804,635	
2014	Univ. of No Texas	$108,988	1.25	1	102330	102330	$211,318	
2010	EVMS	$709,264	1	1	103480	103480	$812,744	46
2011	EVMS	$598,892	1	3	103480	310440	$909,332	
2012	EVMS	$712,607	1	8	103480	827840	$1,540,447	
2013	EVMS	$640,532	1	2	103480	206960	$847,492	

Table 15. Continued. Non-HBCUs' Licensing Cost and Supply Capacity Data

					Supplier Costs (Cij)			
	Non-HBCUs	LEGAL FEES	Size TTO Staff	Total Licensing Deals	Annual Salaries	TTO Staff Labor Expense	Total Expense	No. of Inventions
		(a)	No. FTES			(b)	(a + b)	Supply Capacity
								(Ci)
2010	Rice Univ.	$1,313,527	4.07	11	102330	1125630	$2,439,157	396
2011	Rice Univ.	$1,970,946	4.2	12	102330	1227960	$3,198,906	
2012	Rice Univ.	$2,186,289	5	13	102330	1330290	$3,516,579	
2013	Rice Univ.	$2,230,730	4.5	12	102330	1227960	$3,458,690	
2014	Rice Univ.	$2,178,333	5	14	102330	1432620	$3,610,953	
2010	Univ. of Alabama	$70,724	1	2	83950	167900	$238,624	81
2011	Univ. of Alabama	$42,759	1	4	83950	335800	$378,559	
2012	Univ. of Alabama	$60,132	1	2	83950	167900	$228,032	
2013	Univ. of Alabama	$58,239	1	2	83950	167900	$226,139	
2010	Louisiana Tech	$233,700	1	2	81250	162500	$396,200	65
2011	Louisiana Tech	$160,800	1	2	81250	162500	$323,300	
2012	Louisiana Tech	$136,041	1	5	81250	406250	$542,291	
2013	Louisiana Tech	$145,883	1	3	81250	243750	$389,633	
	Median Values	**$479,457**	**1**	**7**	**98,990**	**665,145**	**1,154,163**	**65**

Max Z = $\sum_i \sum_j$ Cij Xij

s.t. the following constraints:

$\sum_i$ Xij ≥ D_j

(i.e. amounts of patented inventions to be licensed from i to j need to be greater than the demand)

$\sum_j$ Xij ≤ S_i

(i.e. amounts of patented inventions to be licensed from i to j need to be less than or equal to supplies)

$X_{ij} \geq 0$

In addition, each supplier (i.e. licensing specialist) would realistic not close more than 5 deals per year.

Table 15 provides cost and supply capacity data.

- The patenting and licensing costs are legal expenditures that are reported in the Association of University Tech Managers (AUTM) annual licensing survey (AUTM, 2013).
- The TTO staff size as full time equivalents (FTEs) is provided in the AUTM annual licensing survey. Here, the licensing staff FTEs were used.
- Staff labor expenses can be calculated as the product of the annual salaries and the full time equivalents. The US Department of Labor, Bureau of Labor Statistics wage data by state was used for annual salaries in legal occupations. Legal occupation salaries were chosen since they are more conservative estimates as they are higher than salaries such as for marketing and sales professionals which are also relevant to tech licensing. The legal occupation salaries follow (US Department of Labor, 2013):
    - Baylor College of Medicine, TX, $100,760
    - Georgia Regents University, GA, $97,670
    - Medical Univ. of South Carolina, SC, $74,940
    - Wake Forest University, NC, $85,650

- University of North Texas Health Science Center, TX, $100,760
- Eastern Virginia Medical School, VA, $101,500
- Rice University, TX, $100,760
- University of AL Huntsville, AL, $83,950
- Louisiana Tech, LA, $81,250.

The number of inventions provide supply capacity and a gross count of the number of patents that the universities owned was used. This data comes from the US Patent and Trademark Offices (USPTO) Patent Full-Text database (PatFT) (USPTO, 2016b). The PatFT was used to search for all occurrences whereby each non-HBCU is listed as an assignee (i.e. owner) by name. Using these amounts of patents assumes that any prior licenses are non-exclusive licenses and these inventions are still available for future licensing opportunities. Of course, in reality, these non-HBCUs may have entered into exclusive or non-exclusive licensing deals. Table 16 provides the results of the Experiment. The mean total expense of $1,154,163 was divided among the three (3) hypothetical TTO staff persons who serve as suppliers; and among their 12 hypothetical customers who are the potential licensees. Thus, the value $1,154,163/36 = $32,060 was entered as cost data in each of the upper matrix cells of Table 16 for the Microsoft Excel Solver linear programming optimization exercise.

The mean value of 65 total patented inventions was also divided between the three (3) TTO staff suppliers. Typically, in a TTO, the three (3) licensing specialists will be responsible for managing a patent portfolio of a subject matter within the specialist's expertise. So, in this experiment, Supplier 1 manages 15 biotech patents, Supplier 2 manages 10 software patents, and Suppler 3 manages 40 pharmaceutical patents. Although the benchmark for the number of licensing deals that need to be closed in one year is shown in Figure 37 as 7.5 (i.e. 8 deals), in this exercise, the demand was set at 12. The goal is for each Supplier to close one deal each month.

The values shown in the lower matrix of Table 16 are the results of the Microsoft Excel Solver optimized solution for maximizing the patent licensing revenues while meeting customer demands and other constraints. The goal is to recuperate the TTO's labor and patenting legal costs.

Rows 1, 2 and 3 in Table 16 above contains licensing cost data for licensing from the TTO licensing specialists herein called Suppliers (i) 1, 2 and 3 to the Customer destinations. The destinations are the Customers (j) denoted by the columns A to L in Table 16.

The upper matrix simply supplies the cost information. For example, cell A1 = $32,060 to license supplies of patented inventions from Supplier 1 to Customer A.

The Supply column in the upper matrix provides the supply in terms of amount of patented inventions that each Supplier is responsible for licensing. So, for example, Supplier 1 can potentially supply 15 patented inventions to Customers. The Demand row in the upper matrix provides each of the Customer's supply demands. For example, Customer A wants to license one (1) patented invention.

The decisions to be made are located in the lower matrix denoted by rows 5, 6 and 7 for the three (3) TTO Suppliers and columns A through L for the 12 Customers. The decision to be made is how much supply of patented inventions to license from each Supplier to each Customer. This problem is solved using Excel Solver and provides an optimal solution based on a Simplex linear programming algorithm.

In Excel Solver, the total licensing revenues from all of the Customers from all of the Suppliers is maximized by changing the values of the cells in the lower matrix of Table 16. The Customer

demands for patented inventions satisfied are computed and entered into Row 9. The row totals for the Suppliers rows 5, 6 and 7 are also computed and represent the amount licensed out of each Suppliers' supply of patented inventions and received by the Customers.

Next, the constraints are specified in Excel Solver. The goal is to make sure that the amount received by the Customers is equal to or more than what is actually demanded. Recall that the Customer demand totals are in Table 16, Row 4. The total amounts of patents to be licensed must be less than or equal to the amount of supply of patented inventions that are available. Lastly, unconstrained variables are made non-negative because a negative amount cannot be licensed. The Excel Solver solution is provided in Table 16. See cells A, B, C and D and rows 5, 6 and 7. The total maximized licensing revenues is provided in row 9. This will enable the HBCU to plan its labor resources (i.e. the use of its TTO licensing staff suppliers) in order to recuperate their labor costs and patenting legal fees.

Next, in Section 4.3, the results of the job scheduling tool development is discussed.

4.3 HBCU Tech Transfer Job Scheduling Tool Development Results

As noted in Figure 39, this section provides the results of the university tech transfer job scheduling tool experimentation.

4.3.1 Job Scheduling Tool Development

The total duration for each TTO staff person's job task was computed. From a coarse grain approach, it was assumed that they should all work 8 hours. In the experiment, the goal was to minimize the squared difference between the amount every person has to work, and the 8 hours they should work optimally. But in the more general case, when there are fewer than 24 hours, the algorithm can minimize to the mean duration per person.

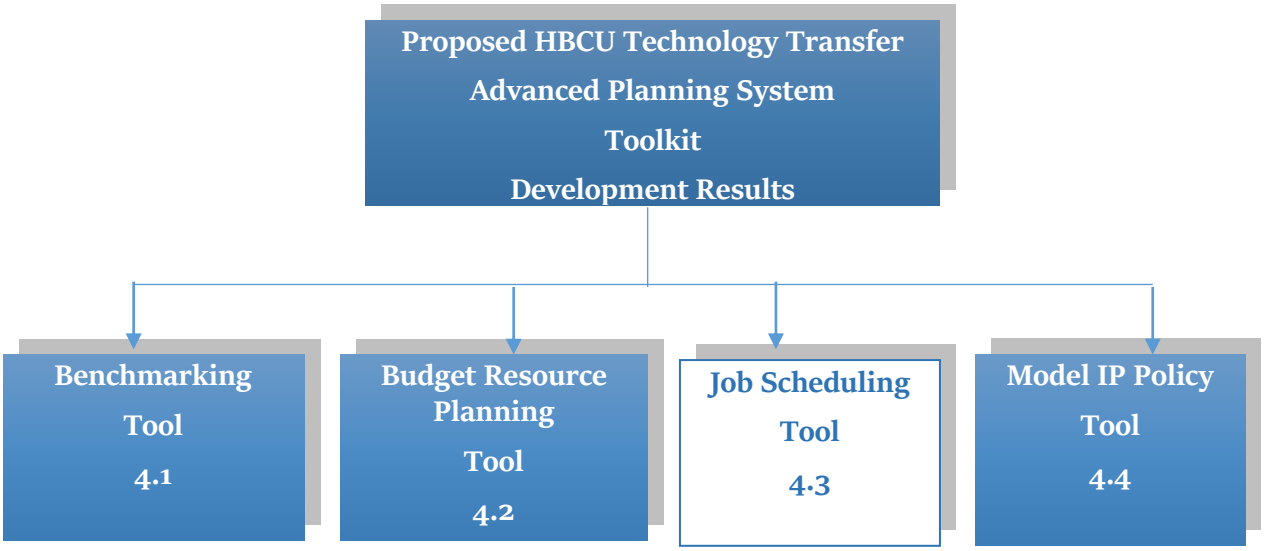


Figure 39. Job Scheduling Tools Development Results § 4.3

Using the simulated annealing algorithm, a *runif* command in R programming was used to get a random probability between 0 and 1. This was multiplied by the current temperature. This is the amount of 'disturbance' or measure of the likelihood that a worse solution is selected. The h value sequence plot of the sequence of states is shown in Figure 40 and the decrease in disturbance in shown in Figure 41. It's not very obvious after 1,000 iterations, but it is visible.

The results successfully showed that all of the workers work exactly 8 hours and some jobs are simply not carried out. The tech transfer office manager can gain notice of which jobs are not or cannot be carried out. With this tool, the convergence of both the standard deviation and the mean for either of the candidate distributions is monitored. See Figure 42. The proposed candidate distributions are independent of the state of the chain at any given time. This Metropolis Hastings (MH) algorithm converges fast and provides a solution instantly.

This optimization minimizes the total delay and produces the tech transfer job schedule shown in Figures 43 and 44. The allocation of jobs to the TTO staff persons is generated in the model

solution list called *mod$sol.list*. The start and end times for the jobs are generated in the vector *mod$all.times*.

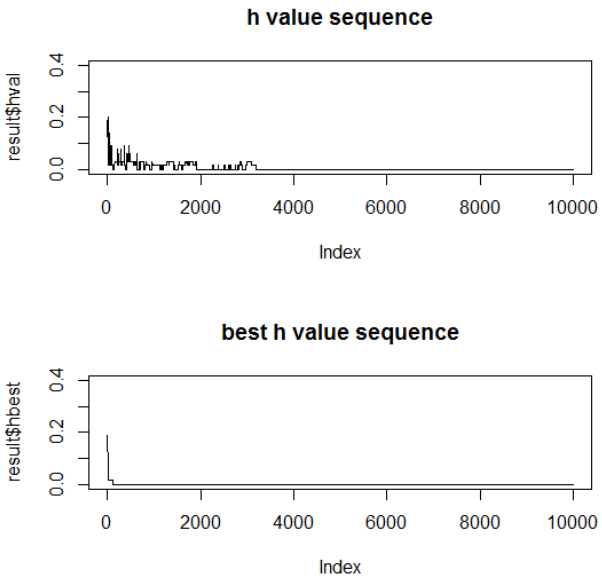


Figure 40. h value sequence plot

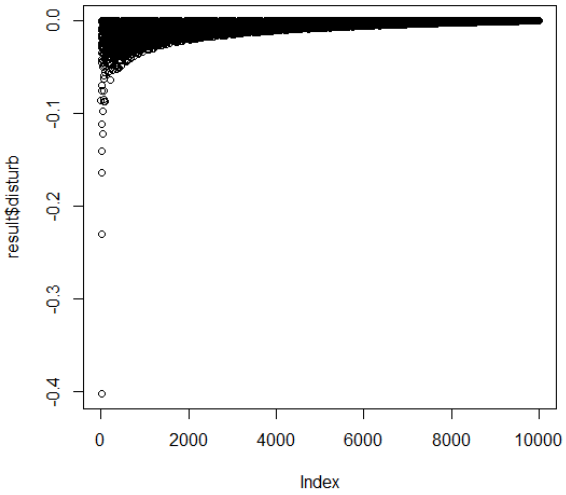


Figure 41. Decrease of Disturbance

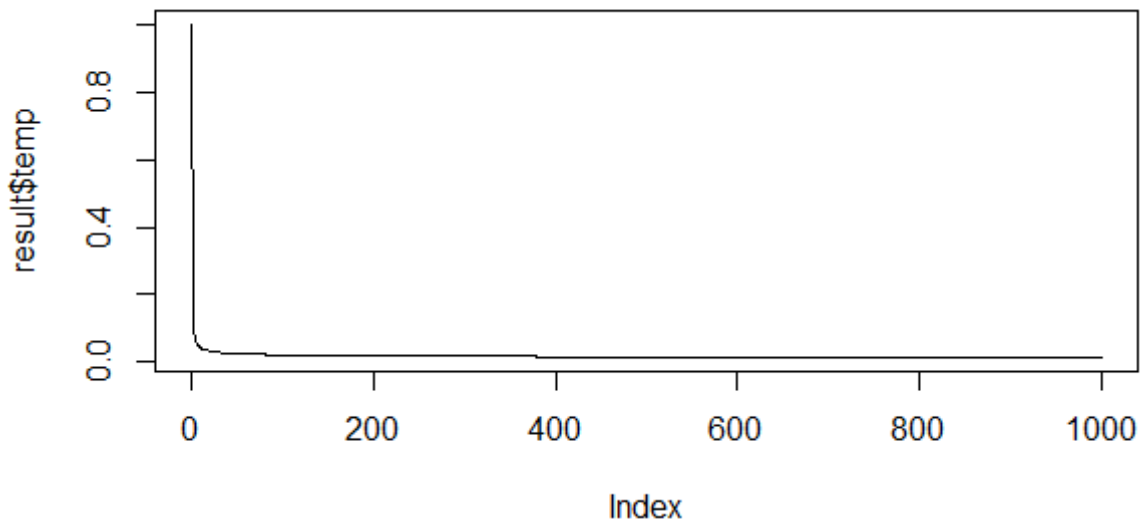


Figure 42. University Tech Transfer Job Scheduling Simulation Convergence

```
> mod$sol.list
[[1]]
[1] 10  1  7  4  2  8

[[2]]
[1] 6 3

[[3]]
[1]  9 11  5

> mod$all.times
$t1
 [1]  2  9  4  7 12  0  6 13  0  0  6

$t2
 [1]  6 13 12  9 18  4  7 14  6  2 12
```

Figure 43. Optimized Job Schedule

Person 1 starts with job 10 which starts at t=0 and ends at t=2;

Then Person 1 continues with job 1 which starts at t=2 and ends at t=6;

The Person 1 continues with job 7 which starts at t=6 and ends at t=7; and

so forth for Persons 2 and 3. These were manually put into Microsoft Excel.

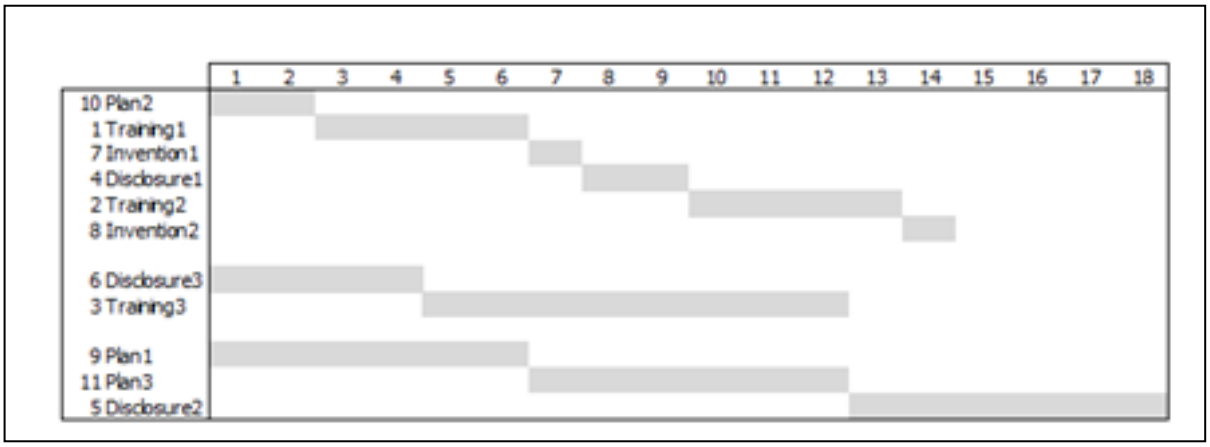


Figure 44. Gannt chart solution to University Technology Transfer Job Scheduling using Simulated Annealing

4.3.2 Comparison to Commercially Available Scheduling Tool

TTO job scheduling was conducted using a Microsoft Excel Solver template by Edwin Straver of Frontline Systems (Straver, 2001). The results are shown in Figures 45 and 46. Please note that worker speed was not taken into consideration in the experiment. Also, instead of minimizing payroll cost, the objective was to minimize the difference in the due time and completion time (DT-CT).

Figure 46 shows that since the TTO only has 3 employees, the 11 tech transfer jobs were split between 3 TTO employees and each job task are shown in Figure 46 as 1 through 11.

Although some jobs were assigned to the TTO employees, the Excel Solver could not find a feasible solution for which all of the constraints could be satisfied. Jobs 7-10 did not get assigned. Therefore, in comparison to the use of Excel Solver, the meta-heuristic simulated annealing program converged to an optimal solution that satisfied the constraints. The Excel Solver personnel scheduling tool by Slaver did not find a feasible solution and did not schedule all of the jobs to all three TTO staff persons. The use of simulated annealing for job scheduling statistically guarantees finding an optimal solution (Ingber, 1993).

The job scheduling tool experimentation illustrates how advanced optimization can be used to schedule TTO staff job tasks in a very quick and simple manner. The budget resource planning tool was illustrated earlier as a simple and less advanced optimization tool that TTO directors can use to better manage their resources financially. Lastly, in the next Section 4.4, the results of the Model IP Policy tool's development are discussed.

				DT Day		1	2	3	4	5			DT (days)	DT (hrs)	CT (hrs)	DT-CT
Jobs	***Days off***		***Empl***		***Sun***	***Mon***	***Tue***	***Wed***	***Thu***	***Fri***	***Sat***					
1	*Saturday, Sunday*		1		0	1	0	0	0	0	0		1	8	4	4
2	*Saturday, Sunday*		1		0	0	0	0	1	0	0		4	32	4	28
3	*Saturday, Sunday*		1		0	0	0	0	0	1	0		5	40	4	36
4	*Saturday, Sunday*		1		0	0	0	1	0	0	0		3	24	2	22
5	*Saturday, Sunday*		1		0	0	0	1	0	0	0		3	24	2	22
6	*Saturday, Sunday*		1		0	0	0	0	1	0	0		4	32	2	30
7	*Saturday, Sunday*		1		0	0	1	0	0	0	0		2	16	1	15
8	*Saturday, Sunday*		1		0	0	0	0	1	0	0		4	32	1	31
9	*Saturday, Sunday*		1		0	1	0	0	0	0	0		1	8	2	6
10	*Saturday, Sunday*		1		0	0	0	0	1	0	0		4	32	2	30
11	*Saturday, Sunday*		1		0	0	0	0	1	0	0		4	32	2	30
		Sched Totals:	11		0	2	1	2	4	1	0					
		Total Demand:			0	11	11	11	11	11	0					
	Pay/Employee/Day:															
	Payroll/Week:				DT-CT:		254									

Figure 45. Use of commercially available Edwin Straver Excel Solver for Personnel Scheduling

Amount of time that each employee will take (not adjusted for speed)														*Schedule assigned to*												
Job	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***		***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***Tot***	
EE1- 1	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	0	1	0	0	0	0	0	1	2
EE1- 2	4	4	4	2	2	2	1	1	2	2	2		0	1	0	0	0	0	0	0	0	0	0	1	4
EE1- 3	4	4	4	2	2	2	1	1	2	2	2		0	0	1	0	0	0	0	0	0	0	0	1	4
EE1- 4	4	4	4	2	2	2	1	1	2	2	2		0	0	0	1	0	0	0	0	0	0	0	1	2
EE2- 5	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	1	0	0	0	0	0	0	1	2
EE2-6	4	4	4	2	2	2	1	1	2	2	2		1	0	0	0	0	0	0	0	0	0	0	1	4
EE2 -7	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	0	0	0	0	0	0	0	0	0
EE3 - 8	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	0	0	0	0	0	0	0	0	0
EE3- 9	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	0	0	0	0	0	0	0	0	0
EE43- 10	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	0	0	0	0	0	0	0	0	0
EE3- 11	4	4	4	2	2	2	1	1	2	2	2		0	0	0	0	0	0	0	0	0	0	1	1	2
					Totals								1	1	1	1	1	1	0	0	0	0	1	7	20
					Demand								1	1	1	1	1	1	0	0	0	0	1		

Figure 46. Excel Solver TTO Personnel Scheduling

4.4 HBCU Tech Transfer Model IP Policy Development Results

As noted in Figure 47, this section provides the results of the university tech transfer Model IP Policy tool. Correlation coefficients (also known as r values) were computed for all of the aforementioned AUTM STATT database fields and NRC faculty quality and university health sciences research programs' quality database fields for data associated with Baylor, U North Texas, Wake Forest, Rice and the University of AL Huntsville. The correlations are shown in Table 17.

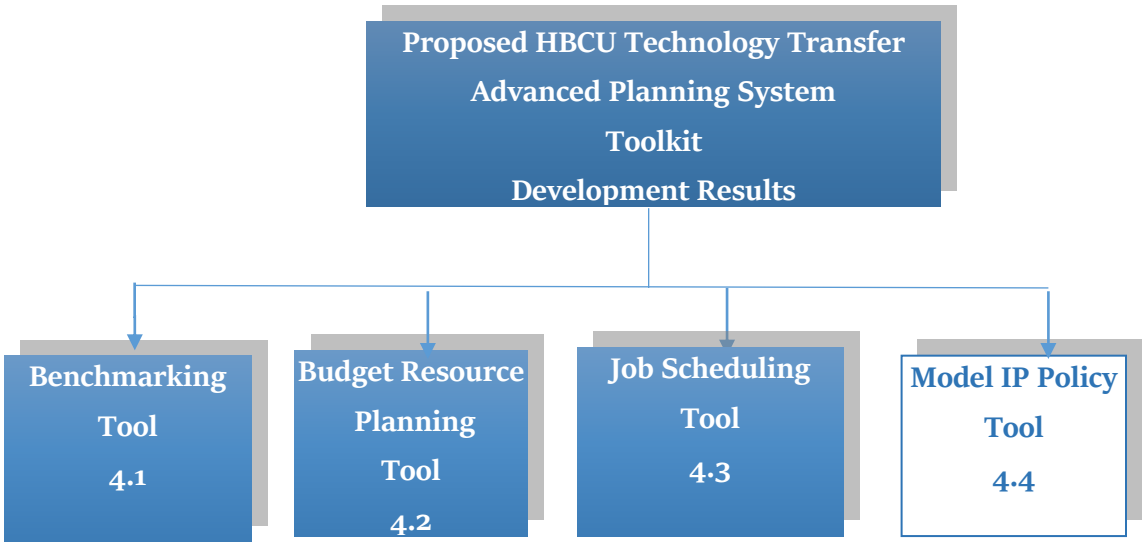


Figure 47. Model IP Policy Tool Development Results § 4.4

These correlation coefficients are carefully interpreted because there are some misleading schemes for interpreting correlation coefficients.

For example, it is misleading to use the common classification of r values as follows:

- ≥ 0.90 as 'very high',
- 0.7-0.89 as 'high',
- 0.3-0.69 as 'medium', and
- Between zero and 0.3 as 'low' (Kirk, 2007).

What constitutes high or low depends on what is being correlated with what and the intended use of the r values (Kirk, 2007). This is particularly important if the observed values are the result of testing and test reliability and validity is at issue. This is not the case here. Herein this study, the intended use of the r values is to predict whether any one variable will likely increase or decrease if the other increases or decreases. Therefore, "each pair of measurement variables are examined to determine whether the two measurement variables tend to move together – i.e., whether large values of one variable tend to be associated with large values of the other (positive correlation), whether small values of one variable tend to be associated with large values of the other (negative correlation), or whether values of both variables tend to be unrelated (correlation near 0 (zero))" (Microsoft, 2016).

4.4.1 Correlation Discussion

In correlation research, the alpha level is the willingness to be wrong when a relationship between two (2) variables is stated and a common alpha level is 0.05 in educational research (Siegle, 2009). In order to assess whether or not the correlation coefficients in Table 17 meet this requirement, a Pearson's Correlation Coefficient table of critical values was used to find the intersection of the alpha 0.05 and 3 degrees of freedom (i.e. five (5) non-HBCUs less 2). This exercise revealed a minimum correlation coefficient of 0.878

which is necessary in order to state with 95% confidence that a relationship exists (Siegle, 2009).

The correlation coefficients of that are ≥ (+) 0.878 were studied. The following nine (9) insightful relationships were discovered:

1. The number of Other TTO staff (herein referred to as 'Other FTEs' full time equivalents (FTEs) and Licensing staff FTEs positively relate to invention disclosures and start up formations. This make sense given that the more invention disclosures and start-ups to be managed by the TTO staff, having more staff will be required.
2. In addition, the number of Other FTEs positively relates to patent applications filed for the same reason as with relationship 1 above.
3. Total research expenditures positively relate to the total license agreements executed. Therefore, having more sponsored research results in more licensing agreements.
4. The number of Licensing FTEs positively relate to the number of publication citations and the percent of faculty engaged in inter-disciplinary research. Thus, it can be surmised that the more a faculty member is engaged and creating significant research results worthy of citation, the more TTO licensing staff that will be required to support the increased level of research engagement.
5. The number of Licensing agreements positively relates to faculty size per program. The more licensing agreements that are desired, the more research faculty required.
6. The number of Start-ups formed positively relate to the percent of faculty engaged in inter-disciplinary research, and to the percent of Assistant Professors. The relationship between the number of start-ups formed and the Assistant Professors

is stronger than their relationship to the percent of Tenured Professors at these select non-HBCUs.

7. Legal fees positively relate to the percent of Tenured Professors. This is quite fascinating and may be due to the Tenured faculty having more experience; more or less engagement with the intellectual property legal counsel.
8. The number of publications per the number of allocated faculty members per program positively relates to the percent of faculty with honors and awards.
9. More interesting than the relationship No. 8 above is that the percent of faculty with honors and awards, gross licensing income and the number of start-ups positively relate to the percent of female faculty researchers. So, more female faculty researchers may result in more faculty honors and awards, gross licensing income and the number of start-ups.

The correlation coefficients that are ≤ (-)0.878 were also studied:

10. The number of licensing agreements do not correlate to the legal fees. This is probably due to the fact that in-house TTO staff are likely to negotiate and close licensing deals; and the outside legal counsel is primarily utilized for patent prosecution.
11. The number of invention disclosures do not correlate to gross licensing income. However, the number of start-up companies do relate to licensing income positively.
12. The gross licensing income does not correlate to the number of faculty publications or percent of faculty with honors and awards.
13. Legal fees for patenting do not relate to the number of faculty publications.
14. The number of patent applications filed, number of invention disclosures, and percent of faculty with honors and awards do not correlate to the percent of faculty that have grants for their research. However, revenue from licensing and the

number of publication citations are related to the percent of faculty with research grants positively.

15. The only variable related to the percent of non-Asian minorities is the number of faculty publications and the number of start-ups formed. The relationship is a positive one.
16. There is a negative relationship (-0.5713) between the licensing income and percent of non-Asian minority faculty. This is especially important to HBCUs. As licensing income increases the number of non-Asian minority faculty would decrease. Although the r value is of medium strength, this phenomenon would be interesting to track.
17. The number of patent applications filed and the amount of legal fees expended do not correlate to faculty size per program.
18. Having a lower or higher percent of tenured professors does not correlate to an increase or decrease in the number of licensing contracts, number of publications, research dollars, percent of faculty with honors or awards, or the number of invention disclosures. This conflicts with Link et al. (2007) which found that tenured faculty inventors are more likely to participate in university technology transfer than non-tenured faculty inventors (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007).
19. There is a medium strength negative relationship (-0.6011) between the percentage of faculty with research funding and the percent of tenured professors. Thus, for example, the more tenured professors, the less the percent of faculty with research grants.
20. The number of Other FTEs in the TTO staff is negatively related to the percent of tenured professors. This r value has a medium strength (-0.5719). This suggests that an increase in the amount of tenured professors would justify a decrease in Other FTEs. This makes sense given the findings in No. 18 above. The tenured

professors do not relate to licensing agreements or invention disclosures, so there would be no need for the increased tech transfer support if there were an increase in the percent of tenured professors.

These 20 correlation inferences, in combination with the literature review findings, help to formulate the Model Intellectual Property (IP) Policy statements.

4.4.2 Model IP Policy

The Model IP Policy is motivated primarily by the University of North Texas Health Science Center (UNTHSC)'s IP Policy. This policy was chosen from among the non-HBCU and HBCU IP policies because this non-HBCU has most of the desired tech transfer program features which were revealed in the literature review. The UNTHSC's IP Policy encourages the use of equity licensing, a TTO, and an IP committee. The university's Academic Affairs Faculty and Tenure policy counts patenting toward tenure and promotion; and the university has a venture capital fund, and release time for research.

The UNTHSC's IP Policy was edited to include all of the tech transfer best practices. In addition, the existence of a medical school or health science medical research results such as in pharmaceuticals and biomed is desirable because royalties are hefty (M. Wright, Burley, Sue, Mosey, Simon, 2004). Thus, using this health science center's intellectual property policy as a model is in alignment with the medical school/ health science desired component of successful tech transfer programs. The Model IP Policy is provided in Appendix E.

The proposed Model IP Policy is the UNTHSC's IP policy edited to include the following policy statements gleaned from the correlation study:

1. HBCUs should commit to having adequately staffed TTO since this positively relates to invention disclosures, start up business formations, publications and patent applications filed.
2. HBCUs should assertively work to increase their R&D grants and contracts since these expenditures positively related to the number of licensing agreements executed.
3. HBCUs need an increase of faculty size per program since this positively relates to licensing deals.
4. HBCUs need to encourage faculty engagement in inter-disciplinary research since this positively relates to start-up business formations.
5. HBCUs need to encourage diversity in their faculty hiring. Gender matters. The percentage of female faculty is positively related to the percentage of honors and awards, gross licensing income, and the number of start-up businesses that are formed.
6. HBCUs need to encourage start-up business formations since this is positively related to the gross licensing income.

Additional IP policy statements are gleaned from the literature review summary §2.4 as follows:

1. Hiring competent and well compensated TTO Staff:
    a. Educated
    b. Experienced
    c. Skilled in marketing
    d. Skilled in negotiations
    e. Skilled in supporting spin-off businesses[77]

[77] Sources: ("HBCU Innovation and Entrepreneurship Collaborative," 2014; A. N. S. Link, Donald S.; Bozeman,Barry 2007; Mowery, 2002; S. Shane, 2002; S. S. Shane, Toby, 2002; D. S. Siegel, Waldman, David A., Atwater, Leanne E., Link, Albert N. , 2003; D. S. Siegel, Waldman, David, Link, Albert 2003a; D. Wright, 2013; M. B. Wright, Sue; Mosey, Simon 2004).

2. Having a flexible, non-bureaucratic, entrepreneurial supportive university culture that:
    a. embraces and licenses to university spin-offs, and
    b. clearly expresses rules for faculty & student entrepreneurial business engagement[78]
3. Having a university and TTO that works to overcome cultural barricades between industry, TTO staff, faculty, and IP attorneys by:
    a. Increasing social relationships
    b. Increasing networking
    c. Building relationships
    d. Improving communication
    e. Increasing faculty engagement[79]
4. Having faculty that is willing to be continually involved in tech transfer with service such as:
    a. Consulting arrangements with licensees
    b. Technical adviser
    c. Marketing adviser
    d. Business adviser[80]
5. Having flexible, non-bureaucratic, entrepreneurial supportive university culture that:
    a. embraces and licenses to university spin-offs
    b. clearly expresses rules for faculty & student entrepreneurial business engagement
6. Providing Venture capital[81]
7. Encouraging faculty to spend more time on grants related research to increase tech transfer[82]
8. Encouraging the Tenured faculty with successful research programs to increase their tech transfer engagement since they are more likely to engage in tech transfer[83]
9. Embracing Equity licensing

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[78] Sources: (Link, 2005; M. B. Wright, Sue; Mosey, Simon 2004)

[79] Sources: (Dahl, 2015; "HBCU Innovation and Entrepreneurship Collaborative," 2014; Mustar, 2006; Owen-Smith, 2001; E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999; D. S. Siegel, Waldman, David A., Atwater, Leanne E., Link, Albert N. , 2003; D. S. Siegel, Waldman, David, Link, Albert 2003a; Tahvanainen, 2008; D. Wright, 2013)

[80] Sources: (Friedman, 2003; D. S. Siegel, Waldman, David, Link, Albert 2003a, 2003b; M. Wright, Burley, Sue, Mosey, Simon, 2004)

[81] Sources: (S. S. Shane, Toby, 2002; D. S. Siegel, Waldman, David, Link, Albert 2003a)

[82] Sources: (A. N. Link, Siegel, Donald S., Bozeman, Barry 2007)

[83] Sources: (A. N. S. Link, Donald S.. 2007; A. N. S. Link, Donald S.; Bozeman,Barry 2007)

    a. TTOs should engage in equity licensing rather than seeking cash from start-ups
    b. TTOs should seek lower royalties from start-ups [84]
10. Having a TTO that is adequately resourced:
    a. Legal budget
    b. Well compensated TTO staff
    c. In-house venture capital program (esp. for medical related inventions)
11. Presence of a Business Incubator
12. Existence of a medical school [or] health science medical research results such as in:
    a. Pharmaceuticals
    b. Biomed

    because the royalties are hefty[85]
13. Having a TTO that is selective about tech transfer funding investments and that prioritize the type of technology they will invest in such as:
    a. Software
    b. Biotech
    c. Electrical engineering

    because these are easier to license[86]
14. Having a university that seeks increased research funding in these areas:
    a. Engineering
    b. Life sciences
    c. Chemistry
    d. Information Technology[87]
15. Adequately rewarding and incentivizing faculty researchers to participate in university tech transfer
    a. Royalty sharing
    b. Credit toward promotion[88].

[84] Sources: (Di Gregorio, 2003; G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005; E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999; S. Shane, 2002; S. S. Shane, Toby, 2002)

[85] Source: (M. Wright, Burley, Sue, Mosey, Simon, 2004)

[86] Source: (M. Wright, Burley, Sue, Mosey, Simon, 2004)

[87] Source: (O'Shea, 2005)

[88] Sources: (Friedman, 2003; Lach, 2004, 2008; A. N. Link, Siegel, Donald S., Bozeman, Barry 2007; A. N. S. Link, Donald S.. 2007; D. S. P. Siegel, Philip Phan, 2005) (D. S. Siegel, Waldman, David, Link, Albert 2003a)

The UNTHSC 's Academic Affairs Faculty and Tenure policy which counts patenting toward tenure and promotion; and the university has a venture capital fund, and release time for research were added to the IP Policy.

4.5 Limitations

This study is not without limitations. One over-arching limitation is that it does not provide an analytical comparison of the diversity of the 24 Doctoral HBCUs' and 9 non-HBCUs' financial portfolios. Besides federal and industry research funding, it would be interesting to compare these schools' private donations and tuition incomes. It would be interesting to discover to what extent these two (2) income streams is used for R&D investments and tech transfer; and whether they positively correlate to licensing revenue generation.

Another over-arching limitation is that this research does not address how best to integrate the proposed tools into an information technology communication network. Information communication networks are advocated for increasing faculty engagement in university technology transfer (D. Wright, 2013). Such advanced planning information technology tools will aid in advancing information knowledge sharing networks which will increase the HBCUs' faculty research engagement in technology transfer. Score cards are also advocated (Spivey, 2009).

Use of advanced planning system tools can improve decision making; and perceptions of university technology transfer service competencies and performance. The limitations for each of the four (4) tools developed in this study are described next.

4.5.1 Benchmarking Tool

The non-HBCUs' selection criteria include financial ability based on potential tuition which depends on student enrollment; and on the non-HBCUs being in the lower quartile of licensing revenue earnings. However, this study does not take into account a comparison of the Doctoral HBCUs' endowments to non-HBCUs' endowments. HBCU endowments are lower than their non-HBCU counterparts (R. J. R. Charles V. Willie, Ronald Brown, 2006; Juan Williams, 2004). This would require a study of the size and use of the endowments. Of particular interest is whether and how much of these schools' endowments are used for technology transfer supply chain relevant development. This would include investments in research lab facilities, research equipment, endowed chairs for faculty researchers and the like.

Another limitation is the available data. The concept model for university technology transfer shown in Figure 22 of the Research Method Chapter III depicts a number of input factors gleaned from the literature review. However, the following internal resources were not analyzed in this study and they include:

I. Human resource inputs
    a. Quality of the TTO staff at HBCUs and non-HBCUs – i.e. their education and experience in technology transfer;
    b. The willingness of the HBCU and non-HBCU faculty to work with their TTO;
    c. HBCU faculty quality was not evaluated because only one of the schools, Howard University, participates in the NRC Faculty Quality survey;

II. Organizational resource inputs
    a. The prestige and reputation of the HBCUs and non-HBCUs based on rankings;

b. Whether if the HBCUs and non-HBCUs are land grant, public, private, for-profit or not for profit;
c. The level and extent of tech transfer educational training and campus awareness at the HBCUs and non-HBCUs;
d. Whether the HBCUs and non-HBCUs are considered to have an entrepreneurial supportive culture and climate as measured by their flexibility, strictness, bureaucracy and autonomy;
e. The HBCUs' and non-HBCUs' TTO organizational structures;
f. The level and extent of the HBCUs' and non-HBCUs' marketing with travel, trade conferences, printed materials, websites, social media, press releases, media coverage, calls and emails;
g. The involvement of multiple supporting organizations in providing business training and expertise such as the business school faculty, DOD funded Procurement Technical Assistance Centers (PTACS), US Small Business Administration funded Small Business Development Centers (SBDCs);

III. Physical resource inputs
a. Presence of science parks;
b. Presence of incubators; and
c. Proximity to high-tech clusters and corridors.

4.5.2 Budget resource planning tool

Advanced planning systems rely on historical demand data to forecast and manage future demand (B. M. Fleischmann, Herbert, 2003). This dissertation research is limited in that it does not rely on any historical data for the demand for HBCUs' and non-HBCUs' patents. It is assumed that for all of the 9 non-HBCUs' patents (i.e. 65 on average), industry would

be interested in all of them. It is also assumed that all of these patents are available for licensing. This is not necessarily the case because some of the patents may have already been exclusively licensed. Thus, it is assumed that if any were licensed, they were licensed non-exclusively. It is also assumed that all of the patents in the non-HBCUs' portfolio are still viable and desirable technologies. So, the impact of the level and extent of technological advancement is not taken into consideration.

Further, the true demand for university patents would require the collection of information over time about past licensing deals, industry requests for more information about certain university patents and the potential match between industry needs for technologies and patents that are available. This exercise becomes more challenging since industry may reach out directly to a faculty inventor rather than the TTO staff regarding their technological needs. These requests need to be captured in a database.

4.5.3 Job scheduling tool

The theory of distribution management is a system dynamics idea applied to production distribution (Forrester, 1961, 1993). The supply chain management of the steps required to move products or services from the suppliers to customers is required in production distribution management. However, the development of the job scheduling tool is limited to the scheduling of the TTO staff and not the entire supply chain. This is due to control issues. For example, the scheduling does not take into account tasks upstream of the TTO staff job tasks such as the amount of time that a faculty member takes to review documentation sent to the TTO by outside patent counsel during patent prosecution. Both the outside patent counsel and TTO staff would likely need the faculty inventor to be engaged and to provide his or her input.

Further, the scheduling does not take into account downstream of the TTO job tasks such as the amount of time that an industry partner takes to review a draft of a licensing agreement or patent prosecution documentation when there is co-inventorship between the university's faculty and the industry partner's employees. Taking into account all estimated completion times and deadlines for job tasks by all parties in the university technology transfer supply chain will make the job scheduling tool more comprehensive and overcome this limitation.

4.5.4 Model IP policy tool

The primary limitation of the Model IP Policy Tool is that it does not take into consideration the fact that each university has a different culture and different policy makers. University policies get drafted and voted on. In this study, the North Texas Health Sciences' IP Policy was chosen as the template for the Model IP Policy and was revised to reflect findings in the literature review and correlation analysis of 21 variables related to university R&D and technology transfer. Yet, the campus culture at the North Texas Health Sciences might be quite different than at the HBCUs.

4.6 Discussion

Universities learn from their own experience as well as the experience of others (M. F. Feldman, Irwin; Bercovitz, Janet; Burton, Richard, 2002). The social comparison theory component of the proposed theoretical framework and lessons learned from social comparison theory research provides lessons on how HBCUs can best learn from non-HBCUs. The theory of distribution management component of the proposed theoretical framework for this research teaches the importance of supply chain management. In particular, it is important to develop models for the strategic and tactical planning of supply chain management (Amaro, 2008).

At HBCUs, patenting has to become widely accepted and it has to become part of the campus culture. The university technology transfer supply chain network is largely a marketing and sales operation. The faculty, staff, leaders and students should all be discussing how to innovate to match industry needs, file for patents, develop marketing plans, find potential licensees, pitch to licensees and close deals.

HBCUs' barriers to building successful technology transfer supply chain networks is their lack of funds. It takes money to make money. They will need funds to pay for patent prosecution, patent fees, TTO staff salaries, marketing materials, travel to trade conferences to pitch their patents and faculty expertise and to learn about industry and federal government agency needs. The entire HBCU technology transfer supply chain needs to be fueled and ignited by increasing R&D grantsmanship.

With respect to the proposed paradigm shift of HBCUs from being largely teaching oriented to research focused, Joel Barker advocates that organizational leaders have problems solving their problems when they lack sophistication, do not know how, and/or technological tools (Barker, 1992). Thus, the level of sophistication of the 24 Doctoral HBCU faculty researchers should be assessed. The proposed assessment is necessary because any lack of sophistication toward being appropriately assertive about competing for research grants and contracts would be barriers to HBCUs' technology transfer success. The competition for government and industry research grants and contracts requires an entrepreneurial spirit in that the faculty researchers should make rounds, attend events, and network with the funding gatekeepers in order to build relationships. As with small business development, funding gatekeepers may be more likely to fund researchers that they have come to know, like and trust. If the HBCU researchers are uncomfortable with this or lack the time or time management skills, then their current grantsmanship training and faculty development needs to be assessed. Further, the 24 HBCUs' current status as

this micro-foundational level should be compared to the 9 selected non-HBCUs' grantsmanship level of sophistication. This study focused on developing the following technological and non-technological tools.

4.6.1 Benchmarking tool

It is predicted that it will take the 24 Doctoral HBCUs several years to ramp up to the recommended performance benchmarks. For example, with respect to patents, the 24 Doctoral HBCUs have much fewer patents than the 9 comparison non-HBCUs. See Table 18 for the comparison. Patenting is expensive and each patent can take 2-3 years to issue.

4.6.2 Budget resource planning tool

The traditional supply chain network from product manufacturing to customer sales and support is not the same as for the proposed university technology transfer supply chain network and its required distribution management. The primary difference is that in the traditional supply chain network, there is typically mass production and mass sales volumes in a steady stream of supply and demand that needs to be managed. However, on the contrary, in the university technology transfer supply chain, there are occasional transfers of patent products (Tatikonda, 2003).

4.6.3 Job scheduling tool

Advanced supply chain planning addresses decisions about the coordination, design and short term scheduling of supply chain processes (B. M. Fleischmann, Herbert, 2003). Currently, there is no scholarly literature referencing the use of job scheduling tools in university tech transfer. The *AUTM Technology Transfer Practice Manual* for tech transfer professionals does not reference such use either.

Table 18. Comparison of HBCU and Non-HBCU Patents (1976 – July 2016)

HBCU PATENT ASSIGNEES	No. of Patents Owned	Non-HBCU PATENT ASSIGNEES	No. of Patents Owned
MOREHOUSE SCHOOL OF MEDICINE	45	Baylor	418
HOWARD	36	Rice	396
FLORIDA A&M UNIVERSITY; FLORIDA AGRICULTURAL AND MECHANICAL UNIVERSITY	29	Wake Forest	284
HAMPTON	22	Univ of AL	81
AL A&M	15	Louisiana Tech	65
CLARK ATLANTA	13	EVMS	46
NC A&T	9	Med Univ of SC	35
TUSKEGEE UNIV	8	Univ of No TX	33
UNIV MD EASTERN SHORE	6	Georgia Regents	8
JACKSON STATE	5		
AL STATE	3		
FAYETTEVILLE STATE	3		
MEHARRY MED	3		
BOWIE STATE	2		
TX SOUTHERN	2 (Year 2014)		
MORGAN STATE	1 (Year 2016)		
DELAWARE STATE	1 (Year 2011)		
VA STATE	1 (Year 1997)		
GRAMBLING	0		
NORFOLK STATE	0		
PRAIRIE VIEW	0		
SC STATE	0		
SOUTHERN	0		
TN STATE	0		
Median No. of Patents	3		65
Source: (USPTO, 2016b)			

There are manual chapters that discuss docketing systems with manual file management and scanned files (Sadowski, 2006); database management (Cleary, 2006); and electronic records management systems that include auto reminders for deadlines and decision support (Argawal, 2006). However, none of these TTO management tool publications mention job scheduling for TTO staff tasks. So, the use would require advocacy, and the marketing of success stories. Job scheduling is crucial because it has the potential for improving staff accountability and trust between the TTO staff and faculty. However, TTO staff that value their academic freedom and autonomy may resist the use of job scheduling tools.

4.6.4 Model IP policy tool

Table 3 in the Literature Review lists a number of IP policies that have been published by university technology transfer scholars. It is assumed that the 24 Doctoral HBCU leaders have not studied those policies thoroughly and incorporated them into their current IP policies. HBCU leaders can take the time to compare the Model IP Policy to their current IP policy and recommend changes where appropriate for their paradigm shift toward becoming more research oriented.

Given the differences in campus cultures among all institutions of higher learning, the Model IP Policy would likely have to be revised to reflect what is important and significant to each individual HBCUs' faculty members and administrators. Yet, it is important not to lose sight that a key component of this research's theoretical framework is the paradigm effect theory. The goal is a cultural shift for HBCUs from being teaching oriented to being more research focused. Yet, there are other cultural characteristics other than teaching versus research that would likely come into play when the HBCU's IP policies are discussed and debated.

CHAPTER V
CONCLUSION

5.1 Findings

The questions that this study explores include:

1. Given that the problems that non-HBCUs face with university technology transfer will likely equally or more challenging for HBCUs, what are the problem areas with non-HBCUs' university technology transfer?
2. What theoretical framework for research can be used to develop advanced planning system tools to help HBCUs with technology transfer?
3. What advanced planning system tools should be developed and used by HBCUs to relieve the university technology transfer problems?

In this exploration, it was discovered that HBCUs are still relevant and serve the special niche of educating economically disadvantaged, rural, and first generation students. The HBCUs have graduated 40% of the US black STEM students and 60% of America's black engineers.

HBCUs' face financial woes due to increasing dependence on government assistance, donations from alums and tuition for operating expenses. Non-HBCUs are much more

advanced in acquiring funding for research expenditures. This research has fueled technology commercialization activities which have resulted in licensing revenues.

HBCUs are behind the non-HBCUs in research and tech transfer. The most telling evidence of the disparity in R&D expenditures is shown in Figure 34 and here in Figure 48.

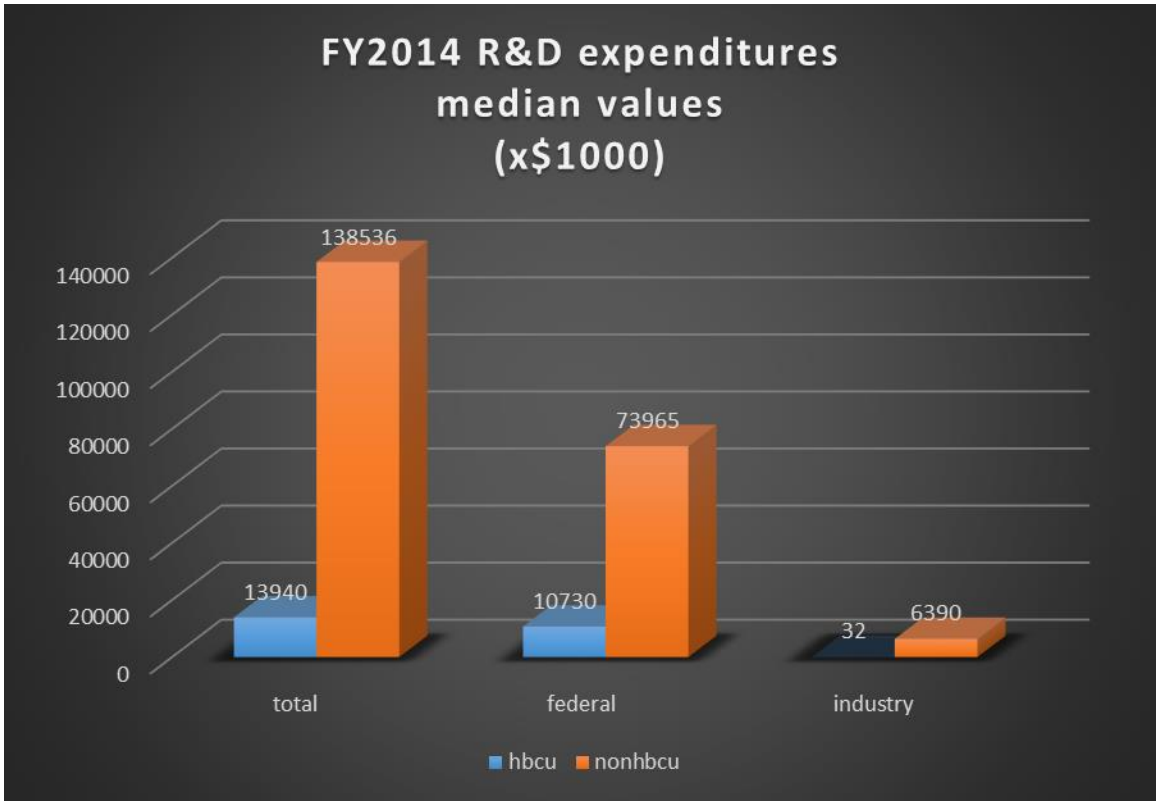


Figure 48. Disparity in HBCU R&D Expenditures

Research funding from government agencies is very different than the mandated federal assistance from the federal government which began at the very onset of HBCUs' existence with the Freedmen's Bureau and continued as mandates in the 1980s with the Carter administration. Research grants and contracts have to be competed for and HBCUs still

struggle with developing entrepreneurial campus cultures that have faculty and administrator with the willingness to learn and act in an aggressive manner to compete for these funds. Many HBCU leaders and faculty continue to debate over whether or not to forge a research culture or to remain teaching institutions.

5.1.1 Theoretical Framework

There is no shared, well-articulated underlying theory of university technology transfer. This will be especially problematic for HBCUs since theoretical frameworks provides a structure to support explanations for why research problems exist. The problem here is that there is a lack of HBCU engagement in tech transfer. This study researches why HBCUs lag behind non-HBCUs in tech transfer and provides a novel theoretical framework for researching how to explain and explore the phenomenon and solutions.

Theories closely related to technology transfer and the comparison of HBCUs to non-HBCUs were explored. It was discovered that a new theoretical framework for researching HBCU tech transfer should include the resource based view, social comparison theory, theory of distribution management and the paradigm effect theory.

With respect to the resource based view, the resources required for tech transfer led to an exploration of the Resource Based View which teaches that if resources are so unique and not imitable, then they are sources of competitive advantage (Barney, 1991).

With regard to social comparisons between HBCUs and non-HBCUs led to an exploration of Festinger's Social Comparison Theory which teaches that groups gain accuracy and clarity about their opinions and abilities by comparing themselves to others in similar proximity and with similar abilities. When individuals and groups ask themselves if they

can perform a job, they compare themselves to other individuals or groups who have performed the job already. (Festinger, 1954). HBCU representatives would be more likely rate their performance as above average on subjective and vague, uncertain attributes such as idealism than on more specific attributes such as licensing income generation (Festinger, 1954; Greenberg & Ashkanasy, 2007). Thus, any tool kit that is developed for HBCUs to compare themselves to should be specific with objective measurable attributes. This motivates the need for a benchmark tool in the toolkit.

University technology transfer is viewed as a supply chain network between faculty researchers in their research labs, TTOs that have inventories of inventions much like a commercial store, and industry partners who are customers seeking to acquire the inventions. The fact that university technology transfer is a supply chain network led to an exploration of Forrester's Theory of Distribution Management (Forrester, 1961, 1993). Forrester advocated that systems dynamics is the process of combining the theory, method and philosophy required to analyze the behavior of a system to provide a common foundation. Since institutions in a supply chain are so interlaced, system dynamics impact product research, engineering, sales and promotions. In applying the systems dynamic process of combining theory, method and philosophy, all four (4) of these theories are combined in this study and they inform the development of tools which provide methods that the HBCUs can use to develop their tech transfer programs. The 4 theories form the theoretical framework for this research that provides the foundation to support explanations for why the HBCUs' tech transfer problems exist and what can be done about it.

Lastly, the fact that in order for HBCUs to strengthen their financial situation, they need to make a paradigm shift led to an exploration of the Paradigm Effect theory advocated by Kuhn and Barker (Kuhn, 1996). It is difficult for HBCUs to notice the need to shift when

their existing paradigm is so strong. The HBCUs are still holding tight to their rich past history of educating ex-slaves and serving largely as teaching institutions rather than as research institutions. So, HBCU leaders need to learn how to engage in strategic explorations to anticipate their future better.

It was discovered that the HBCUs which are Doctoral Research institutions have made substantial progress since earlier studies of their research and tech transfer capabilities in the 1990s by the DOD and by the National Academy of Sciences in 2009 ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009; Sullivan, 1996; Tractell, 1991). Both HBCUs and non-HBCUs have university technology transfer challenges. Despite challenges faced by non-HBCUs, they still report licensing revenue earnings to AUTM. Over the past 35 years, many non-HBCUs have generated enormous amounts of licensing revenue income. Although most HBCUs' will likely encounter more challenges than the non-HBCUs, they can still engage in tech commercialization as a viable means to alleviate their dependence on fund raising and tuition income. See Table 19 for a HBCU progress report and Tables 9 and 12 for details about the tech transfer program features.

Beyond theory, there is a need for practice. Thus, this study explored industrial engineering simple management, optimization and advanced optimization tools that can be used by the HBCUs to help them to start their tech transfer activities in a manner that would alleviate problems that some non-HBCUs face. These problems include tech transfer task processing delays and budget resource planning shortfalls.

Table 19. HBCU Research & Tech Transfer Progress Report

	Past HBCU Study Findings 1991-1996 DOD, 2009 Natl Academy of Science/NSF	Metrics	HBCUs 2016	Non-HBCUs in comparison 2016
1	Few incentives & financial rewards for faculty to engage in research & tech transfer	% royalty sharing	75	100
2	Tenure and promotion policy does not reward faculty engagement in research & tech transfer	% with tech transfer counting toward tenure & promotion	20.8	11.1
3	Small or no grants and contracts infrastructure	% with stand-alone Offices of Sponsored Programs	87.5	100
4	Little marketing of R&D capabilities	FUTURE RESEARCH OPPORTUNITY		
5	Tech transfer overlooked	% with TTO support services	50	100
6	Limited resources	R&D funding	HBCUs are woefully behind the non-HBCUs See Figure 48.	
7	High teaching loads	% with release time for research	75	88.9
8	Credibility gap and negative brands	FUTURE RESEARCH OPPORTUNITY		
9	Lack of entrepreneurial culture	FUTURE RESEARCH OPPORTUNITY		

Sources: ("Partnerships for Emerging Research Institutions Report of a Workshop," 2009; Sullivan, 1996; Tractell, 1991).

Four (4) tools to help alleviate these problems include:

1. performance benchmarks,
2. resource planning,
3. reducing tech transfer job task processing delays with scheduling, and
4. a Model intellectual property policy.

Combined these tools make up an advanced planning system. It was discovered that HBCUs can benefit from implementing this advanced planning system. Advanced planning tools make it possible to manage supplies to meet demands. Further, the literature review uncovers that advanced planning information technology tools aid in advancing informal knowledge sharing networks which increase faculty engagement in tech transfer (B. M. Fleischmann, Herbert, 2003).

5.1.2 Benchmarking Tool

The simplest tool in the toolkit is the benchmarking tool. It is simply a list of benchmarks culled from the non-HBCUs that the Doctoral degree offering HBCUs can evaluate themselves against. This tool meets a critical need because research and development operations need a better way to control technology transfer input variables (Gibson, 1991). This tool was developed with the theoretical framework's resource based view, social comparison theory and theory of distribution management in mind.

The benchmarking tool provides quality standards for the HBCUs to use. These quality standards are taken from Figure 37 and are listed here in Table 20. They provide aspirational goals for which HBCUs can strive to achieve.

Table 20. HBCU Tech Transfer Benchmarking Tool

Type of Resources	Annual Goals	Benchmarks
INPUTS		
Human Resources: Faculty	No. of Publications per allocated research faculty member	1.54
	No. of citations per publication	3.55
	% Faculty w/ research grants	90
	% Faculty w/ honors & awards	0.28
	% Non-Asian minorities	3
	% Women	23.2
	% Faculty engaged in inter-disciplinary research	47.4
	Faculty size per program	37
	% Assistant Professors	17
	% Tenured Professors	71
Human Resources: TTO Staff	No. of TTO Staff FTEs serving to license technology: • Educated with MBAs, PhDs, JDs • Experienced in tech commercialization • Well compensated	2 FTEs
	No. of other TTO staff	2.25 FTEs
Human Resources: Sponsored Research Staff	No. of Pre-award Grant Officers	1
	No. of Post-award Grant Officers	1
Organizational Resources	Stock of patents	65
	Patent applications filed	32
	Budget for expenditure on external IP legal counsel	$0.51M
	Total Research Funding level	$96M
	Federal Government Research Funding level	$75M
	Industry Research Funding level	$7.7M

Table 20. Continued. HBCU Tech Transfer Benchmarking Tool

Type of Resources	Annual Goals	Benchmarks
OUTPUTS		
	Annual Spin off Biz Formations	2
	Licensing Agreements	7.5
	Licensing revenues	$397,596

The HBCUs need R&D programmatic goals which include improving faculty researcher and TTO staff quality. It also includes making sure there is pre-award and post-award sponsored research staff. The pre-award staff person(s) will help faculty researchers with new research opportunity identification, proposal writing and submissions, negotiations, and grant and contract awards. The post-award staff person(s) will help faculty researchers with understanding project monitoring, record keeping, accounting, reporting and closeout (Tractell, 1991) Throughout project execution and in the reporting phase, inventions need to be disclosed to the HBCU.

5.1.3 Budget Resource Planning Tool

Financial resource planning is a best practice in tech transfer. Patenting and marketing to potential industry licenses is very expensive. This is a real problem and balancing act for TTO directors (Silverman, 2007). With each invention disclosure, TTOs must decide whether to invest funds, patent and market the technology quickly or they miss opportunities. A study of TTO directors revealed that 20.3% of the TTOs have to be self-sufficient and fund at least 50% of their operating budgets (Abrams, 2009). Thus, budget resource planning is crucial for all research universities and this is even more crucial an issue for budget strapped HBCUs. The level of resources committed to university tech transfer programs is the greatest determinant of success (Crowell, 2005).

5.1.4 Job Scheduling Tool

In order to alleviate the problem with job task delays in the university technology transfer process, job scheduling techniques were explored. It was discovered through experimentation that simulation annealing is an advanced optimization tool that is well suited for job scheduling. In comparison to a commercially available Excel Solver scheduling tool, the meta-heuristic simulated annealing program converged to an optimal solution that satisfied the constraints. The Excel Solver personnel scheduling tool by Slaver did not find a feasible solution and did not schedule all of the jobs to all three TTO staff persons. The use of simulated annealing for job scheduling statistically guarantees finding an optimal solution (Ingber, 1993). The job scheduling tool experimentation illustrates how advanced optimization can be used to schedule TTO staff job tasks in a very quick and simple manner.

5.1.5 Model Intellectual Property Policy Tool

A Model IP Policies for HBCUs to use was developed by studying the IP policies used by the 24 Doctoral HBCUs and nine (9) non-HBCUs included in this study. The University of North Texas Health Science Center (UNTHSC)'s IP Policy was chosen as a boilerplate from among the non-HBCU and HBCU IP policies because this non-HBCU has most of the desired tech transfer program features which were revealed in the literature review. The UNTHSC's IP Policy encourages the use of equity licensing, a TTO, and an IP committee. The university's Academic Affairs Faculty and Tenure policy counts patenting toward tenure and promotion; and the university has a venture capital fund, and release time for research. UNTHSC was also ideal because the existence of a medical school or health science medical research results such as in pharmaceuticals and biomed is desirable because royalties are hefty (M. Wright, Burley, Sue, Mosey, Simon, 2004). Thus, using this

health science center's intellectual property policy as a model is in alignment with the medical school/ health science desired component of successful tech transfer programs.

The UNTHSC's IP Policy was edited to include all of the tech transfer best practices gleaned from the literature review and from a correlation analysis of the following 21 non-HBCU technology transfer variables:

1. TTO Licensing staff full time equivalents (FTEs)
2. TTO Other staff FTEs
3. Total Research Expenditure
4. Federal funded Research Expenditure
5. Industry funded Research Expenditure
6. Total Licenses and License Options Executed
7. Invention Disclosures
8. Total Patent Applications Filed
9. Start Up Businesses Formed
10. Gross Licensing Income
11. Legal Fees
12. Number of publications per allocated faculty member
13. Number of citations per publication
14. % faculty with research grants
15. % faculty with honors and awards
16. % non-Asian minority faculty
17. % women faculty
18. % faculty engaged in inter-disciplinary research
19. faculty size per program
20. % assistant professors
21. % tenured professors

The Model IP Policy is provided in Appendix E.

5.2 Recommendations

A university's commitment to research goes hand in hand with university tech transfer success. It is obvious that without research results and inventions, there is no technology

to transfer. HBCUs can bolster their finances with technology licensing revenues just as the well-established non-HBCUs research institutions have been doing for more than 30 years. However, it will take time, effort and more importantly a commitment to research.

5.2.1 Theoretical Framework & Tools

To help with this effort, a novel theoretical framework for HBCU tech transfer research is proposed. This theoretical framework combines the resource based view, social comparison theory, theory of distribution management, and the paradigm-effect theory. The theoretical framework served to guide the research and development of an advanced planning system toolkit. It is recommended that HBCU leaders commit to using this study's proposed advanced planning system toolkit which includes a:

- Benchmarking tool,
- Budget resource planning tool,
- Job Scheduling tool, and
- Model HBCU Intellectual Property Policy.

With respect to benchmarking, Table 20 provides a list of recommended metrics for HBCUs to strive to achieve and to evaluate themselves against. With regard to budget resource planning, as noted in the 2013 Ford Foundation funded study (Clay, 2012), HBCUs need to commit to mount a campaign for resources and make use of the proposed Budget Resource Planning Tool for tech transfer. This simple linear programming based optimization tool will help HBCUs make the most of their limited resources. In addition, the proposed job scheduling tools based on the advanced optimization technique of simulated annealing will help HBCUs alleviate the non-HBCU experienced problem of tech transfer job task delays.

Note that all of the factors except the sponsored research staffing have been analyzed using correlations to assess how strongly these variables are related to each other.

5.2.2 Paradigm Shift

It is recommended herein that the paradigm shift proposed in this research can be handled in this manner:

a. The use of the proposed tool kit for HBCU tech transfer should be suggested as a new paradigm to be used as a management tool in a case study by one or more willing HBCUs to demonstrate an ability to solve a few noteworthy challenges that the old paradigm did not resolve. They can manage within the tool kit paradigm and lead the shift between their old prevailing paradigm and the new one (Barker, 1992). This would result in a success story.

b. Through promotional marketing both internal to individual HBCUs and via external social media marketing, leaders in HBCUs can be encouraged to accept the new paradigm (i.e. the proposed tool kit) as action requiring faith.

c. With adequate funding and other support, the new paradigm will gain ground, strength and drive. HBCU leaders will need to be encouraged to make investments in their technology transfer infrastructure, staff training, and faculty training.

5.2.3 Proposed Paradigm Shift Structure

The proposed paradigm shift structure is described in Table 21. It is imperative that HBCUs use job scheduling to alleviate technology transfer job task delays. In addition, improved IP policies that promote meaningful technology transfer support among and between the faculty and administrators will help HBCUs achieve the paradigm shift from being teaching oriented toward being research oriented with robust tech transfer programs.

Table 21. HBCU Tech Commercialization Paradigm Shift

Players	Paradigm Shift Methodology
Paradigm shifters (outsiders): - Scholars; especially including this HBCU tech transfer tool kit developer - non-HBCU partners - industry partners - HBCU alumni	The proposed tool kit for HBCU tech transfer should be suggested as a new paradigm to be used as a management tool in a case study by one or more willing HBCUs to demonstrate an ability to solve a few noteworthy problems that the old paradigm did not solve. They can manage within the tool kit paradigm and lead the shift between their old prevailing paradigm and the new one (Barker, 1992). This would result in a success story.
Paradigm pioneers (insiders): - Faculty inventors - Student entrepreneurs - HBCU leaders (Presidents, Provosts, Vice Presidents, Deans, Department Chairs) - HBCU managers & directors	Through promotional marketing both internal to individual HBCUs and via external social media marketing, leaders in HBCUs can be encouraged to accept the new paradigm (i.e. the tool kit) as an act of faith.
Paradigm leadership: - HBCU leaders (Presidents, Provosts, Vice Presidents, Deans, Department Chairs) - HBCU managers & directors	With adequate funding, and convincing persuasive and influential support, the new paradigm will gain momentum and velocity. HBCU leaders will need to be encouraged to make investments in their technology transfer infrastructure, staff training, and faculty training.

Additional recommendations include:

1. Developing faculty mentoring programs whereby the HBCU faculty are mentored by successful non-HBCU and HBCU faculty on time management techniques so that they learn how to balance teaching, service, grantsmanship, research, writing for journal publication, media outreach and conference presentations.
2. As advocated by Clay (2012), HBCUs should commence fundraising campaigns to raise funds to improve R&D resources (Clay, 2012).

3. HBCU faculty, chairs, deans, and other leaders should make routine rounds to visit federal agencies and industrial representatives in an entrepreneurial manner in order to build relationships with people that make research funding decisions. This is a common business development technique that government contractors engage in and is in alignment with the HBCUs need to cultivate their entrepreneurial cultures.
4. HBCU faculty, chairs, deans, and other leaders need business sales and marketing training on how to improve their branding and how to elevate their public profiles in a manner that positively promotes their rich past history and current research capabilities
5. HBCUs should invest in succession planning. Since the HBCUs have small R&D budgets, their research faculty membership is small. So, many may rely on a few small teams of researchers or a few high profile researchers. If these researchers depart the university, there needs to be plans for having replacements to succeed them.
6. The refinement of existing HBCU IP policies with the use of the Model IP Policy as a guide will require that advocates explain that the best practices terms come from a thorough review of the literature herein this study and the correlation analysis. This will help champions of IP Policy improvement to achieve faculty and administrator buy-in.
7. TTOs and faculty researchers need to closely document their interactions with potential industry partners. In particular, it would be helpful to build historical records of licensing deals, industry's expressed needs, and how faculty expertise and HBCU owned patents match the industry needs. The better the historical data, the better HBCU tech transfer can be optimized.
8. HBCUs' TTOs should create secure information sharing portals that integrate the benchmarking, budget resource planning, job scheduling and Model IP policy tools

in combination with score cards and the databases commonly used by TTOs for data collection and retrieval. If this information were shared with faculty researchers, it would foster transparency and build trust.

9. Given that it can take years for the HBCUs to be able to increase the number of patents that they own to the non-HBCU median value of 65, HBCUs should focus on licensing their invention disclosures rather than their patents. They can then have their licensee make the patent investment. With this type of invention licensing, the licensee will usually agree to share royalties after they recuperate their patenting expenses.

Just as the industrial sector helped HBCUs with philanthropy at their onset, the industrial engineering profession can be of service today. This study illustrates how engineering management and optimization techniques can be used to alleviate university technology transfer problem areas which include the need for a theoretical framework for research, benchmarks, budget resource planning and the need to alleviate processing delays.

5.3 Future Research Opportunities

Table 4 in the Literature Review Chapter II provides a number of gaps in the research on university technology transfer. More specific to the study of HBCUs, this study was limited to selecting non-HBCUs for which Research Doctoral HBCUs could compare themselves to. Thus, a future research opportunity would be to conduct a more fine-grained study of all HBCUs that offer post baccalaureate degree programs. In particular, a study of the HBCUs that offer STEM related post baccalaureate degree programs would be insightful.

Further, case studies of HBCUs that are willing to actually work on achieving the benchmarks and implement this study's recommendations over a period of perhaps 5- 10 years are future research opportunities. The proposed case studies should monitor the

methods that the HBCUs use to fund their research and tech transfer resource investments. The proposed case studies should also include a study of the use of the budget resource planning and job scheduling optimization tools. The case studies can reveal whether a paradigm shift into an increased research and tech commercialization arena makes a difference for the HBCUs financial situations and whether this initiative decreases their donation and tuition dependence.

In addition, a future research study of methods to increase HBCU engagement in trade organizations such as AUTM; and in surveys such as the AUTM annual licensing survey and the NRC faculty quality survey is needed. The study should uncover reasons why HBCU representatives are reluctant to participate such as:

- Lack of awareness,
- Perceptions of not belonging to or identifying with these organizations,
- Perceptions of disrespect or unfairness,
- Perceived job insecurity due to under performance,
- Not believing in the rankings, or
- Not having effective data collection systems or data collection.

Table 18 pointed out three (3) future research opportunities:

1. Surveys to measure the level and extent to which HBCUs are currently marketing their research expertise, facilities, equipment, hardware and software.
2. Opinion surveys and interviews to measure the credibility gap and negative branding issues.
3. Opinion surveys and interviews to measure the HBCUs progress toward embracing academic entrepreneurship and developing more entrepreneurial cultures.

Future case studies, interviews of HBCU Presidents, and opinion surveys of HBCU research faculty should explore whether, at each HBCU, there is a(n):

- clear, adequate, and well-articulated vision including increasing research and technology commercialization;
- understanding of competitive threats;
- lack of competitiveness;
- leadership with a sophisticated understanding of university strategic positioning, research development and technology transfer;
- leadership that values university research development and technology transfer;
- appropriate teaching load for research faculty;
- adequate lab facilities, equipment, hardware and software;
- adequate R&D matching funds;
- adequate marketing of faculty expertise and the university's other research capabilities;
- any specific instances of the HBCUs' credibility being questioned or of negative branding related to research or the lack thereof; and what was done to cure the problem;
- perception that the HBCU has an entrepreneurial culture;
- high turnover in research faculty, TTO staff and/or research administrators;
- adequate TTO staffing with respect to their pay, education, technology transfer experience, number of deals they have closed, and the amount of licensing revenues they have generated;
- any technology transfer related job tasks delays (e.g. invention disclosure evaluations, patenting decisions, marketing decisions, incompetent licensing negotiations or other frustrations); and
- adequacy of the willingness of the HBCU's faculty researchers to be fully engaged in the technology transfer process by giving their time and energy.

The recommendations in this study can help other emerging research institutions at Minority serving institutions (MSIs), Hispanic serving institutions (HSIs), Native American serving institutions (NASNTIs), Asian American and Native American Pacific Islander-serving Institutions (AANAPISI's). In addition, other HBCUs that do not currently offer doctoral research programs have expressed an interest in technology transfer. Those HBCUs participated in the 2013 HBCU Innovation Summit (Abate, 2013). The schools include Xavier University, Spelman College, Claflin University, Fisk University, Morehouse College, Tougaloo University, Dillard and NC Central. Thus, the proposed theoretical framework for researching HBCU tech transfer and toolkit development can be implemented at these emerging research universities also; and doing so will provide for additional future research opportunities.

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APPENDICES

APPENDIX A – LIST OF HBCUS AND NON-HBCUS

Table 22. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Alabama A & M University Normal AL, 5,333, Public Research Doctoral: Professional-dominant	Agnes Scott College Atlanta GA, 915, Private
Alabama State University Montgomery AL, 5,519, Public Research Doctoral: Single Program-Other	Amridge University Montgomery AL, 631, Private
Albany State University Albany GA, 3,910, Public Post baccalaureate: Education-dominant, with other professional programs	Argosy University Nashville TN, 551, Private
Alcorn State University Alcorn State MS, 3,639 Public Post baccalaureate: Education-dominant, with Arts & Sciences	Armstrong State University Savannah GA, 7,101, Public
Allen University Columbia SC, 660, Private (Not classified)	Auburn University at Montgomery Montgomery AL, 5,084, Public
American Baptist College Nashville TN, 147, Private (Not classified)	Augusta Technical College Augusta GA, 4,379, Public
Arkansas Baptist College Little Rock AR, 899, Private (Not classified)	Baton Rouge Community College Baton Rouge LA, 8,043, Public
Benedict College Columbia SC, 2,444 Private (Not classified)	Baylor College of Medicine
Bennett College Greensboro NC, 633, Private (Not classified)	Birmingham Southern College Birmingham AL, 1,188, Private

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Bethune-Cookman University Daytona Beach FL, 4044, Private Postbaccalaureate: Business-dominant, with Arts & Sciences	Central Carolina Technical College Sumter SC, 4,456, Public
Bishop State Community College Mobile AL, 3,320, Public (Not classified)	Central Virginia University Lynchburg VA, 4,730, Public
Bluefield State College Bluefield WV, 1,563, Public (Not classified)	Christian Brothers University Memphis TN, 1,577, Private
Bowie State University Bowie MD, 5,695, Public Research Doctoral: Professional-dominant	Columbia College Columbia SC, 1,169, Private
Central State University Wilberforce OH, 1,751, Public Postbaccalaureate: Single program-Education	Columbia International University Columbia SC, 1,154, Private
Cheyney University of Pennsylvania Cheyney PA, 1,022, Public Postbaccalaureate: Other-dominant, with other professional programs	Concordia University Austin TX, 2,565, Private
Claflin University Orangeburg SC, 1,866, Private Postbaccalaureate: Business-dominant, with Arts & Sciences	Croswell College Dallas TX, 323, Private
Clark Atlanta University Atlanta GA, 3,485 Private Research Doctoral: Comprehensive programs, no medical/veterinary school	Dallas Christian College Dallas TX, 316, Private
Clinton College Rock Hill SC, 194 (Not classified)	Darton State College Albany GA, 6,195, Public

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Coahoma Community College Clarksdale MS, 2,045, Public (Not classified)	Daymar Institute Nashville TN, 141, Private
Concordia College-Selma Selma AL,546, Private (Not classified)	Delaware Technical Community College Dover DE, 3,031, Public
Coppin State University Baltimore MD, 3.133 Public Postbaccalaureate: Other-dominant, with Arts & Sciences	Durham Technical Community College Durham NC, 5,605, Public
Delaware State University Dover DE, 4,336, Public Research Doctoral: Single program-Education	East Texas Baptist University Marshall TX, 1,247, Private
Denmark Technical College Denmark SC, 1,678, Public (Not classified)	Eastern Virginia Medical School Norfolk VA, 1,017, Public
Dillard University New Orleans LA, 1,200, Private (Not classified)	Faulkner Goucher College Baltimore MD, 2,111, Private
Edward Waters College Jacksonville FL, 929, Private (Not classified)	Faulkner University Montgomery AL, 3,193, Private
Elizabeth City State University Elizabeth City NC, 1.867, Public Postbaccalaureate: Education-dominant, with Arts & Sciences	Flagler College Tallahassee FL, 478, Private
Fayetteville State University Fayetteville NC, 5,899, Public Research Doctoral: Single program-Education	Fontbonne University Saint Louis MO, 1, 997, Private
Fisk University Nashville TN, 646, Private Postbaccalaureate: Single program-Other	Forsyth Technical Community College Winston Salem NC, 9,528, Public
Florida Agricultural and Mechanical University Tallahassee FL, 10,241, Public Research Doctoral: Professional-dominant	Gallaudet University Washington DC, 1,561, Private

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Florida Memorial University Miami Gardens FL, 1,528 Private Postbaccalaureate: Business-dominant, with other professional programs	Georgia Regents University Augusta GA, 8,468, Public
Fort Valley State University Fort Valley GA, 2,594, Public Postbaccalaureate: Other-dominant, with Arts & Sciences	Greensboro College Greensboro NC, 1,012, Private
Gadsden State Community College Gadsden AL, 5,289, Public (Not classified)	Guilford College Greensboro NC, 2,302, Private
Grambling State University Grambling LA, 4,504 Public Research Doctoral: Single program-Education	Heritage College Little Rock AR, 413, Private
H Councill Trenholm State Technical College Montgomery AL, 1,338, Public (Not classified)	Heritage Institute Jacksonville FL, 279, Private
Hampton University Hampton VA, 4,393, Private Research Doctoral: Humanities/social sciences-dominant	Houston Baptist University Houston TX, 2, 910, Private
Harris-Stowe State University St Louis MO, 1,280, Public (Not classified)	Huntingdon College Montgomery AL, 1,110, Private
Hinds Community College-Utica Raymond MS, 11,839, Public Utica MS (Not classified)	ITT Technical Institute Little Rock AR, 289, Private
Howard University Washington DC, 10,265, Private Research Doctoral: Comprehensive programs, with medical/veterinary school	ITT Technical Institute Houston TX, 650, Private
Huston-Tillotson University Austin TX, 1,031, Private (Not classified)	ITT Technical Institute Nashville TN, 525, Private
Interdenominational Theological Center Atlanta GA, 306, Private Postbaccalaureate: Single program-Other	ITT Technical Institute Austin TX, 432, Private

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
J F Drake State Technical College Huntsville AL, 1,062, Public (Not classified)	ITT Technical Institute Jacksonville FL, 591, Private
Jackson State University Jackson MS, 9,508, Public Research Doctoral: Professional-dominant	Jacksonville University Jacksonville FL, 4,157, Private
Jarvis Christian College Hawkins TX, 763, Private (Not classified)	Jefferson State Community College Birmingham AL, 8,542, Public
Johnson C Smith University Charlotte NC, 1,402, Private (Not classified)	John Gupton College Nashville TN, 122, Private
Kentucky State University Frankfort KY, 1,895, Public Postbaccalaureate: Other-dominant, with Arts & Sciences	Johnson & Wales University Charlotte NC, 2,325, Private
Lane College Jackson TN, 1,262, Private (Not classified)	Kaplan College Nashville TN, 323, Private
Langston University Langston OK, 2,482 Public Postbaccalaureate: Other-dominant, with other professional programs	Lincoln College of Technology Nashville TN, 1,856, Private
Lawson State Community College-Birmingham Campus Birmingham AL, 3,090, Public (Not classified)	Lipscomb University Nashville TN, 4,580, Private
Le Moyne-Owen College Memphis TN, 1,006, Private (Not classified)	Louisiana State University Health Sciences Shreveport LA, 856, Public
Lincoln University Jefferson City MO, 3,117, Public Postbaccalaureate: Comprehensive programs	Louisiana State University Health Sciences New Orleans LA, 2,829, Public
The Lincoln University Lincoln University PA, 1,819, Public Postbaccalaureate: Other-dominant, with other professional programs	Lynchburg College Lynchburg VA, 2,713, Private

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Livingstone College Salisbury NC, 1,301, Private (Not classified)	Medial University of South Carolina
Meharry Medical College Nashville TN, 802, Private Research Doctoral: Single program-Other	Meredith College Raleigh NC, 1,872, Private
Miles College Fairfield AL, 1,782 Private (Not classified)	Methodist University Fayetteville NC, 2,463, Private
Mississippi Valley State University Itta Bena MS, 2,222, Public Postbaccalaureate: Other-dominant, with Arts & Sciences	Mid Atlantic Christian University Elizabeth City NC, 162, Private
Morehouse College Atlanta GA, 2,109, Private (Not classified)	Middle Georgia State College Macon GA, 7,989, Public
Morehouse School of Medicine Atlanta GA, 398, Private Research Doctoral: Single program-Other	Millsaps College Jackson MS, 804, Private
Morgan State University Baltimore MD, 7,698, Public Research Doctoral: Professional-dominant	Mountain View College Dallas TX, 8,797, Public
Morris College Sumter SC, 780, Private (Not classified)	Nashville State Community College Nashville TN, 10,007, Public
Norfolk State University Norfolk VA, 6,027, Public Research Doctoral: Professional-dominant	New Orleans Baptist Theological New Orleans LA, 2,638, Private
North Carolina A & T State University Greensboro NC, 10, 725 Public Research Doctoral: STEM-dominant	Notre Dame of Maryland University Baltimore MD, 2,877, Private
North Carolina Central University Durham NC, 7,687, Public Postbaccalaureate: Comprehensive programs	Oglethorpe University Atlanta GA, 1,100, Private
Oakwood University Huntsville AL, 1,939, Private Postbaccalaureate: Single program-Other	Parker University Dallas TX, 922, Private

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Paine College Augusta GA, 848, Private (Not classified)	Pulaski Technical College Little Rock AR, 10,527, Public
Paul Quinn College Dallas TX, 273, Private (Not classified)	Piedmont International University Winston Salem NC, 383, Private
Philander Smith College Little Rock AR, 567, Private (Not classified)	Prince Institute – Southeast Montgomery AL, 102, Private
Prairie View A & M University Prairie View TX, 8,429, Public Research Doctoral: Comprehensive programs, no medical/veterinary school	Queens University of Charlotte Charlotte NC, 2,285, Private
Rust College Holly Springs MS, 963, Private (Not classified)	Randolph College Lynchburg VA, 682, Private
Saint Augustine's University Raleigh NC, 1,016, Private (Not classified)	Remington College – Little Rock Campus Little Rock AR, 229, Private
Savannah State University Savannah GA, 4,915, Public Postbaccalaureate: Other-dominant, with Arts & Science	Remington College – Nashville Campus Nashville TN, 298, Private
Selma University Selma AL, 558, Private Postbaccalaureate: Single program-Other	Richard Bland College of the College of William and Mary Petersburg VA, 1,428, Public
Shaw University Raleigh NC, 1,802, Private Postbaccalaureate: Single program-Other	SAE Institute of Technology Nashville TN, 92, Private
Shelton State Community College Tuscaloosa AL, 4,978, Public (Not classified)	Salem College Winston Salem NC, 1,187, Private
South Carolina State University Orangeburg SC, 3,331, Public Research Doctoral: Single program-Education	Savannah Technical College Savannah GA, 4,784, Public

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Southern University and A & M College Baton Rouge LA, 6,330, Public Research Doctoral: Professional-dominant	South University Austin TX, 156, Private
Southern University at New Orleans New Orleans LA, 2,103, Public Postbaccalaureate: Other-dominant, with other professional programs	Southeast Arkansas College Pine Bluff AR, 1,601, Public
Southern University at Shreveport Shreveport LA, 2,952, Public (Not classified)	Spring Hill College Mobile AL, 1,422, Private
Southwestern Christian College Terrell TX, 164, Private (Not classified)	St Mary's University San Antonio TX, 3,868, Private
Spelman College Atlanta GA, 2,135, Private (Not classified)	St Philip's College San Antonio TX, 10,238, Public
Stillman College Tucsaloosa AL, 1,056, Private (Not classified)	Tennessee College of Applied Technology Nashville TN, 1,014, Public
St. Philip's College San Antonio TX, 10,238, Public Not listed Carnegie	Texas State Technical College Marshall TX, 755, Public
Talladega College Talladega AL, 879, Private (Not classified)	Trevecca Nazarene University Nashville TN, 2,406, Private
Tennessee State University Nashville TN, 9,027, Public Research Doctoral: Professional-dominant	Trinity Baptist College Jacksonville FL, 323, Private
Texas College Tyler TX, 813, Private (Not classified)	Trinity University San Antonio TX, 2,358, Private
Texas Southern University Houston TX, 9,233, Public Research Doctoral: Comprehensive programs, no medical/veterinary school	University of Alabama in Huntsville Huntsville AL, 7,376, Public

Table 22. Continued. List of HBCUs and non-HBCUs

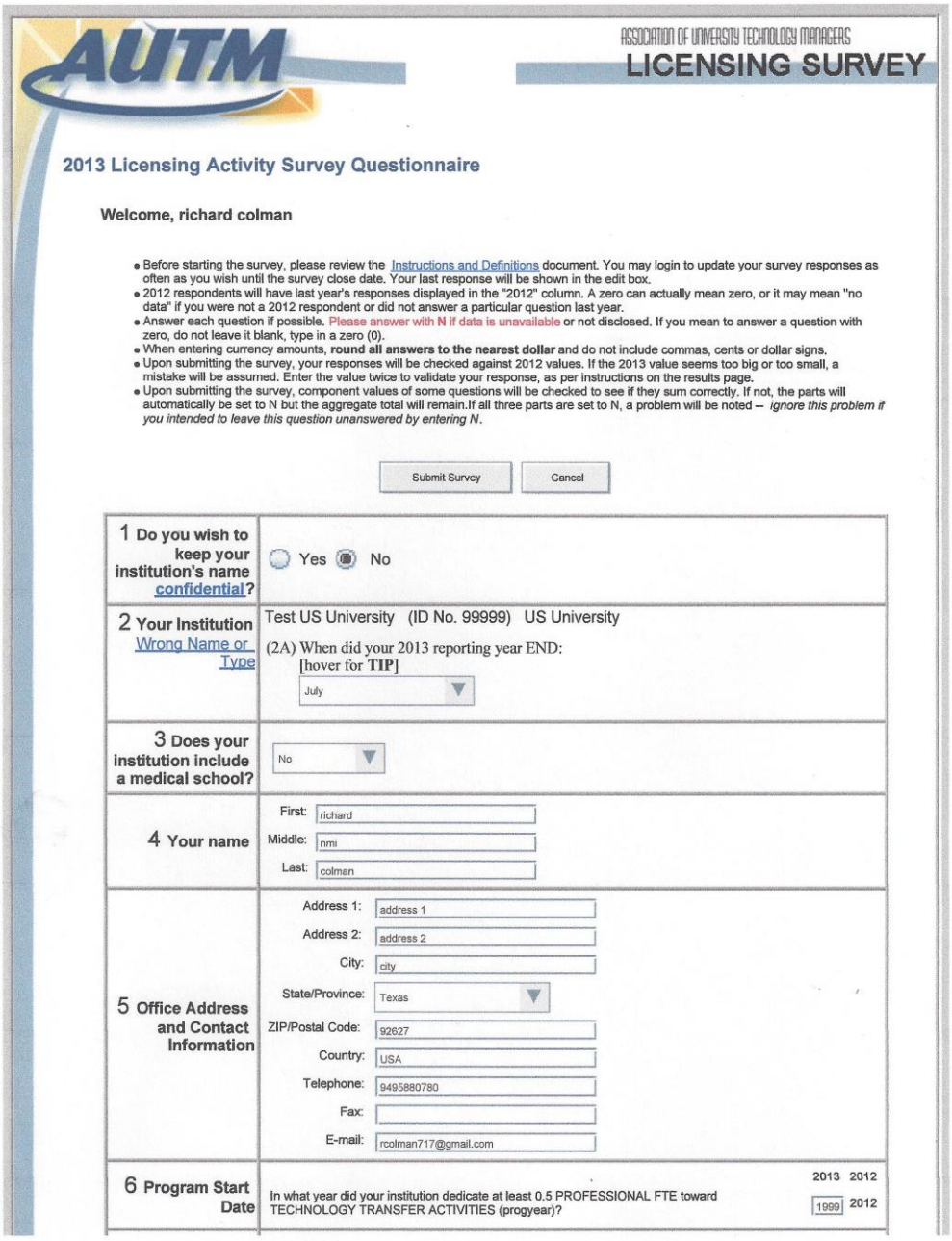
List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
Tougaloo College Tougaloo MS, 900, Private (Not classified)	University of Baltimore Baltimore MD, 6,518, Public
Tuskegee University Tuskegee AL, 3,103, Private Research Doctoral: STEM-dominant	University of Houston Clear Lake Houston TX, 8,164, Public
University of Arkansas at Pine Bluff Pine Bluff AR, 2,513, Public Postbaccalaureate: Education-dominant, with Arts & Sciences	University of Mississippi Medical Center Jackson MS, 2,268, Public
University of Maryland Eastern Shore Princess Anne MD, 4,279, Public Research Doctoral: Professional-dominant	University of Mobile Mobile AL, 1,610, Private
University of the District of Columbia Washington DC, 4,803, Public Postbaccalaureate: Education-dominant, with Arts & Sciences	University of New Orleans New Orleans LA, 9,323, Public
University of the Virgin Islands Charlotte Amalie VI, 2,280, Public Postbaccalaureate: Comprehensive programs	University of Richmond University of Richmond VA, 4,140, Private
University of the Virgin Islands-Kingshill St Croix VI, 2,331, Public[89] Not listed	University of South Carolina Sumter Sumter SC, 924, Public
Virginia State University Petersburg VA, 5,025, Public Research Doctoral: Humanities/social sciences-dominant	University of St Thomas Houston TX, 3,525, Private
Virginia Union University Richmond VA, 1,715, Private Postbaccalaureate: Single program-Other	University of Texas Health Science Center San Antonio TX, 3,148, Public
Virginia University of Lynchburg Lynchburg VA, 324, Private Postbaccalaureate: Comprehensive programs	University of Texas Southwestern Medical Center Dallas TX, 2,374, Public
Voorhees College Denmark SC, 468, Private (Not Classified)	Virginia College Montgomery Montgomery AL, 656, Private

[89] No NCES student enrollment listed. However, the UVI Kingshill Fall 2014 Student Enrollment report shows 2,331 students

Table 22. Continued. List of HBCUs and non-HBCUs

List HBCUs Location, Student Enrollment, Type	List of Non-HBCUs (of similar size based on student enrollment and location to the HBCUs)
West Virginia State University Institute WV, 2,884, Public Postbaccalaureate: Other-dominant, with other professional programs	Virginia Wesleyan College Norfolk VA, 1,459, Private
Wilberforce University Wilberforce OH, 387, Private Postbaccalaureate: Single program-Other	Welch College Nashville TN, 338, Private
Wiley College Marshall TX, 1,351, Private (Not Classified)	Wesleyan College Macon GA, 700, Private
Winston-Salem State University Winston-Salem NC, 5,220, Public Postbaccalaureate: Other-dominant, with Arts & Sciences	West Coast University Dallas Dallas TX, 320, Private
Xavier University of Louisiana New Orleans LA, 2,976, Private Postbaccalaureate: Other-dominant, with other professional programs	Williams Peace University Raleigh NC, 1,007, Private

APPENDIX B - AUTM FY 2013 ANNUAL LICENSING SURVEY



ASSOCIATION OF UNIVERSITY TECHNOLOGY MANAGERS
LICENSING SURVEY

2013 Licensing Activity Survey Questionnaire

Welcome, richard colman

- Before starting the survey, please review the Instructions and Definitions document. You may login to update your survey responses as often as you wish until the survey close date. Your last response will be shown in the edit box.
- 2012 respondents will have last year's responses displayed in the "2012" column. A zero can actually mean zero, or it may mean "no data" if you were not a 2012 respondent or did not answer a particular question last year.
- Answer each question if possible. Please answer with N if data is unavailable or not disclosed. If you mean to answer a question with zero, do not leave it blank, type in a zero (0).
- When entering currency amounts, **round all answers to the nearest dollar** and do not include commas, cents or dollar signs.
- Upon submitting the survey, your responses will be checked against 2012 values. If the 2013 value seems too big or too small, a mistake will be assumed. Enter the value twice to validate your response, as per instructions on the results page.
- Upon submitting the survey, component values of some questions will be checked to see if they sum correctly. If not, the parts will automatically be set to N but the aggregate total will remain.If all three parts are set to N, a problem will be noted – *ignore this problem if you intended to leave this question unanswered by entering N.*

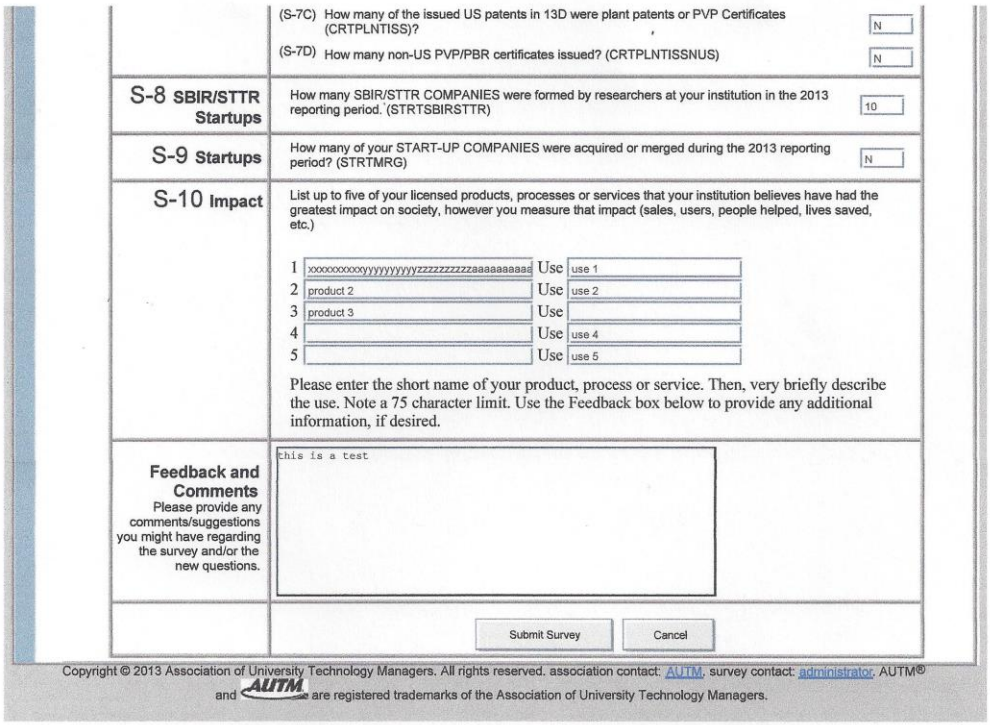
Submit Survey | Cancel

1 **Do you wish to keep your institution's name confidential?**	○ Yes ◉ No
2 **Your Institution** Wrong Name or Type	Test US University (ID No. 99999) US University (2A) When did your 2013 reporting year END: [hover for **TIP**] July
3 **Does your institution include a medical school?**	No
4 **Your name**	First: richard Middle: nmi Last: colman
5 **Office Address and Contact Information**	Address 1: address 1 Address 2: address 2 City: city State/Province: Texas ZIP/Postal Code: 92627 Country: USA Telephone: 9495880780 Fax: E-mail: rcolman717@gmail.com
6 **Program Start Date**	In what year did your institution dedicate at least 0.5 PROFESSIONAL FTE toward TECHNOLOGY TRANSFER ACTIVITIES (progyear)? 2013 2012: 1999 2012

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		2013	2012
	(11C) How much of the LICENSE INCOME was PAID TO OTHER INSTITUTIONS? (lipdin)	$ 12,000	$19
12 Legal Fees Expenditures And Reimbursements		2013	2012
	(12A) Amount spent on external legal fees for patents and/or copyrights? (explgf)	$ 6,000	$25
	(12B) Amount received in reimbursements for these fees from licensees? (reimlg)	$ 4,500	$26
13 IP-Related Activity		2013	2012
	(13A) How many DISCLOSURES were received? (invdis)	30	27
	(13B) How many TOTAL U.S. PATENT APPLICATIONS were filed? (tptapp)	12	28
	(13C) Report the number of NEW PATENT APPLICATIONS FILED? (nptapp)	10	29
	(13C1) Of NEW PATENT APPLICATIONS FILED, how many were filed as US PROVISIONAL PATENT APPLICATIONS (NPTAPPPR)	5	30
	(13C2) Of NEW PATENT APPLICATIONS FILED, how many were filed as US UTILITY PATENT APPLICATIONS (NPTAPPUT)	5	31
	(13C3) Of NEW PATENT APPLICATIONS FILED, how many were filed as NON-US PATENT APPLICATIONS (NPTAPPNUS)	0	32
	NOTE: (13C1) + (13C2) + (13C3) must = (13C) otherwise set 13C1, 13C2 and 13C3 to N		
	(13D) How many U.S. PATENTS ISSUED? (usptis)	3	33
14 Start-Up Companies		2013	2012
	(14A) How many START-UP COMPANIES were formed during fiscal year 2013 that were dependent upon the licensing of your institution's technology for initiation? (strtup)	5	34
	(14B) How many of these START-UP COMPANIES have their primary place of business operating in your home state/province? (strths)	5	37
	(14C) How many START-UP COMPANIES that were dependent upon the licensing of your institution's technology for initiation and were reported in the Survey in this year or in earlier fiscal years became non-OPERATIONAL in fiscal year 2013? (strnop)	2	38
	(14D) How many START-UP COMPANIES that were dependent upon the licensing of your institution's technology for initiation and were reported in the Survey in this year or in earlier fiscal years were OPERATIONAL as of the last day in fiscal year 2013? (stopcm)	12	39
	(14E) Of the START-UP COMPANIES formed in fiscal year 2013 (reported in 14A above), in how many does your institution hold EQUITY? (stupeq)	0	40
15 Licensed Technologies, Post-Licensing Activity		2013	2012
	(15A) Did one or more of your institution's LICENSED TECHNOLOGIES become AVAILABLE for consumer (public) or commercial use in fiscal year 2013? (ltavmk)	Yes	Yes
	(15B) If YES above, how many? (ltav)	5	45
S-1 Clinical Trials Annual amount of research expenditures (include direct and indirect costs) for your institution.	How much of the RESEARCH EXPENDITURES from INDUSTRIAL SOURCES (8C above) was attributed to funding for CLINICAL TRIALS? (clinexp)	$ 50,000	
S-2 Disclosures	How many of the DISCLOSURES (13A) referenced support from a federal grant? (fedinvdis)	30	
S-3 Net Sales of Products	Based on royalty reports received from licensees, what were the net sales of products (ESTIMATED SALES OF LICENSED PRODUCTS) sold in fiscal year 2013 that were covered by LICENSED TECHNOLOGIES? (netsales)	$ 40,000	
S-4 Startup Staffing	What was the total number of FTEs employed by all your START-UP COMPANIES as of December 31, 2013 (or as of the date of their acquisition by another company, if earlier)? (strtfte)	22	
S-5 Disclosures Returned	How many disclosures did you return to your inventors? (invdisret) [hover for **TIP**]	7	
S-6 Design Patents	Of the New PATENT APPLICATIONS FILED, how many were filed as design patents (PATDESGN)	N	
S-7 Plant Patents and Certificates	(S-7A) Of the New PATENT APPLICATIONS FILED in 13C, how many were filed as plant patents? (PATPLANT)	N	
	(S-7B) What is the total number of plant certificates filed (US or non-US) on your new plants, including either plant variety protection (PVP) or plant breeders rights (CRTPLNT)?	N	

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(S-7C) How many of the issued US patents in 13D were plant patents or PVP Certificates (CRTPLNTISS)? N

(S-7D) How many non-US PVP/PBR certificates issued? (CRTPLNTISSNUS) N

S-8 SBIR/STTR Startups

How many SBIR/STTR COMPANIES were formed by researchers at your institution in the 2013 reporting period. (STRTSBIRSTTR) 10

S-9 Startups

How many of your START-UP COMPANIES were acquired or merged during the 2013 reporting period? (STRTMRG) N

S-10 Impact

List up to five of your licensed products, processes or services that your institution believes have had the greatest impact on society, however you measure that impact (sales, users, people helped, lives saved, etc.)

1	xxxxxxxxxxyyyyyyyyyyzzzzzzzzzzaaaaaaaaaa	Use	use 1
2	product 2	Use	use 2
3	product 3	Use	
4		Use	use 4
5		Use	use 5

Please enter the short name of your product, process or service. Then, very briefly describe the use. Note a 75 character limit. Use the Feedback box below to provide any additional information, if desired.

Feedback and Comments

Please provide any comments/suggestions you might have regarding the survey and/or the new questions.

this is a test

Submit Survey Cancel

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APPENDIX C – UNIVERSITY OF TN IRB APPROVAL

THE UNIVERSITY of TENNESSEE
KNOXVILLE
Office of Research & Engagement
INSTITUTIONAL REVIEW BOARD (IRB)

1534 White Ave.
Knoxville, TN 37996-1529
865-974-7697
fax 865-974-7400

September 23, 2015

Clovia Ann Hamilton,
UTK - Industrial & Information Engineering

Re: UTK IRB-15-02300-XM
Study Title: A concept model for HBCU's growth into new or stronger research institutions

Dear Ms. Hamilton:

The Administrative Section of the UTK Institutional Review Board (IRB) reviewed your application for the above referenced project. The IRB determined that your application is eligible for **exempt** review under 45 CFR 46 Category 4: Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded in a de-identified manner. In accord with 45 CFR 46.116(d), informed consent is waived. Your application has been determined to comply with proper consideration for the rights and welfare of human subjects and the regulatory requirements for the protection of human subjects. This letter constitutes full approval of your application (version 1.3) to use data from the AUTM surveys.

Any alterations (revisions) in the protocol must be promptly submitted to and approved by the UTK Institutional Review Board prior to implementation of these revisions. You have individual responsibility for reporting to the Board in the event of unanticipated or serious adverse events and subject deaths.

Sincerely,

Colleen P. Gilrane

Colleen P. Gilrane, Ph.D.
Chair

APPENDIX D – OTHER
UNIVERSITY TECHNOLOGY TRANSFER RESOURCES

Table 23. Other University Technology Transfer Resources

TTO Age	Old TTOs with more experience engage in equity licensing more (M. F. Feldman, Irwin; Bercovitz, Janet; Burton, Richard, 2002). Equity licensing is used frequently when universities license technology to spin-off companies. Several environmental and institutional factors that impact productivity noted in prior tech transfer related research studies including the age of the TTO (J. B. Powers, 2003) (D. S. Siegel, Waldman, David, Link, Albert 2003a). Further, Siegel cites two (2) 2005 research studies by O'Shea, and Locke et al. which emphasize that the specialized expertise and past success of TTOs and their previous success in technology transfer impact the spin offs created by and economic development generated by universities (D. S. Siegel, Veugelers,Reinhilde, Wright, Mike 2007). However, the Chapple team found that having an older TTO office have negative effects on efficiency (Chapple, 2005).
Resources of the University - Type of University - Private or Public, Land grant or not	Siegel et al. cited several environmental and institutional factors that impact productivity noted in prior tech transfer related research studies including whether the research university is private or public (D. S. Siegel, Waldman, David, Link, Albert 2003a). Other factors included whether the research university was a land grant institution. In the book entitled "Innovation Pathways for University Entrepreneurship in the 21st Century", Matthew A. Mars frames the land grant college and university system as a social innovation which advances the economic and social interests of the nation (Mars, 2014). Mars states that the Morill Act of 1862 established the land grant model and that the advancement of economic and social interests is consistent with its originally designed intention dating back to the creation of the Cooperative Extension System enacted by the New Deal during the Great Depression (Mars, 2014). Mars advocates that land grant institutions can help national economies overcome recessions by re-establishing economic stability and growth via workforce development, entrepreneurship education, and promoting the broader dissemination of scientific and technological innovation through technology transfer (Mars, 2014).

Table 23. Continued. Other University Technology Transfer Resources

Resources of the University - Type of University - Private or Public, Land grant or not	Siegel et al. cited several environmental and institutional factors that impact productivity noted in prior tech transfer related research studies including whether the research university is private or public (D. S. Siegel, Waldman, David, Link, Albert 2003a). Other factors included whether the research university was a land grant institution. In the book entitled "Innovation Pathways for University Entrepreneurship in the 21st Century", Matthew A. Mars frames the land grant college and university system as a social innovation which advances the economic and social interests of the nation (Mars, 2014). Mars states that the Morill Act of 1862 established the land grant model and that the advancement of economic and social interests is consistent with its originally designed intention dating back to the creation of the Cooperative Extension System enacted by the New Deal during the Great Depression (Mars, 2014). Mars advocates that land grant institutions can help national economies overcome recessions by re-establishing economic stability and growth via workforce development, entrepreneurship education, and promoting the broader dissemination of scientific and technological innovation through technology transfer (Mars, 2014). Younhee Kim appraised technology commercialization production for 90 research universities using data envelopment analysis to study panel data collected between 1999 and 2007 (Kim, 2013). Using an input to output ratio, Kim reported that university technology commercialization was approximately efficient. This finding indicates a positive shift in average production which is principally attributed to the increasing frequencies in commercial production (Kim, 2013). Kim's work extends previous studies such as the 2003 Siegel study and the 2002 Thursby and Kemp study (Kim, 2013). Kim (2013) found that: (1) with respect to resource management, those that are not capable of achieving their desired objectives are reaching the production of the efficient universities in marketing technology transfer; and (2) the average production of private universities is only 0.9% higher than public universities (Kim, 2013). Anderson et al. used a data envelopment analysis (DEA) method for a productivity study of 54 university TTOs (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). They examined the service industry efficiency aims for certain universities and with respect to inefficient universities, they conducted a peer count (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). The key distinguishing characteristics in this study was whether there existed a medical school; and whether the university was privately or publicly held (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). To be efficient, they concluded that

Table 23. Continued. Other University Technology Transfer Resources

	the average university with high licensing earnings would have to increase their licensing. The study by Anderson et al. found that the variance in university tech transfer efficiencies could not be explained by the existence of university medical schools (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). Also, distinctions between public versus private universities were not significant (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). They recommended that future research on other factors should be examined. These factors include the staffing capacity of TTOs, the influence of various intellectual property policies, and university faculty incentive programs (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). Further, the size of the TTO, closeness to venture capital companies, local financial banking operation headquarters, high-tech company headquarters, and whether the state is prioritizing and supporting higher education should be examined (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007). In addition, there should be an international comparison conducted between countries such as Canada, Europe and Asian countries (T. Anderson, Daim, Tugrul U., Lavoie, Francois F., 2007).
Presence of incubators	Markman et al. (2005) studied 129 universities and although two-thirds of them invested in incubators, most of them did not link the investment (and their interest in new business startups or economic development) to their tech transfer strategies or mission (G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005). Thus, university incubators have a tendency to remain on the edge of efforts for improving regional economic development (G. D. Markman, Phan, Phillip H., Balkin, David B., Gianiodis, Peter T., 2005).
Presence of science parks	At the University of Texas Austin, Stanford University, and the University of Utah, university spin-offs are located in their university research parks. Lease fees are paid by tenants to the universities. Thus science parks are revenue generators. Further, these business often provide jobs for students and university graduates (E. M. H. Rogers, Brad; Hashimoto, Michio; Steffensen, Morten; Speakman, Kristen L.; Timko, Molly K., 1999). Universities with both TTOs and research parks have both improved research performance and tech commercialization (D. Wright, 2013). In Spain, although there was no significant impact of available venture capitalist firms and R&D expenditure in the local region, characteristics of the surrounding region made a difference with respect to the explanation of variance in outcomes for creating academic spin-offs and generating licensing revenues in Spain's research universities (González-Pernía, 2013). Science

Table 23. Continued. Other University Technology Transfer Resources

	parks, TTO staff know-how, and the know-how contained in the university patent collection caused differing licensing outcomes among universities in Spain (González-Pernía, 2013).
Business expertise, training and technical assistance	The Wright team noted that business schools may be able to play more of a role by offering entrepreneurship courses and technology transfer fellowships to faculty researchers (M. B. Wright, Sue; Mosey, Simon 2004) Coding schema is common language and awareness. One difficulty in communication between two disparate groups of participants in work groups that do not share a common technical language is that the coding schema of their work is less efficient (Tushman, 1980). This may be a problem between business school faculty if they attempt to play a role in university tech commercialization and the formation of university startups that TTOs can license technology to. Tushman (1980) teaches that gatekeepers can be more effective when they contact peers directly, mediate contacts, and have a hierarchy that supports these contacts in order to facilitate linking subunits to external information. TTOs should do more for faculty researchers with regard to marketing patented inventions to external potential licensees and positioning themselves more as peer gatekeepers. If the common technical language and coding schema issues can be overcome, then perhaps business schools can play a role in bridging any gaps between TTO staff and faculty inventors. Thus, multi-disciplined TTO staff having both a life or physical science background, legal, and business expertise can overcome the technical language and coding schema dilemma. In addition, the effectiveness of nonacademic TTO staff's social capital related to academic entrepreneurship has been questioned (M. Wright, Hmieleski, Keith M., Siegel, Donald S., Ensley, Michael D., 2007). According to Wright et al. (2007), there are managerial concerns related to potential conflicts of interest and for some, e.g. their compensation. In addition, further research is recommended to study how surrogate entrepreneurs (e.g. whether among TTO staff or business school faculty) should be engaged to include when they can serve in an entrepreneurial capacity themselves, the nature of their business networking and how they are identified, and the level and extent of the role they can play (M. Wright, Hmieleski, Keith M., Siegel, Donald S., Ensley, Michael D., 2007).
Resources of the Local, Regional, and State Government - Economic	Since the late 1980s and early 1990s, the phrase 'knowledge spillover' has been used to describe a non-monetary effect known as an externality which is the exchange of useful technology that needs to be coordinated rather than merely concentrated (Kamecke, 2004). In the locality encircling a university, the Milken Institute report entitled "America's High-Tech Economy" discusses the value of the consequences of commercial activities (known as externalities and

Table 23. Continued. Other University Technology Transfer Resources

growth of tech industries	spillovers) in having a substantial and growing tech industry that is emphasized (D. S. Siegel, Waldman, David, Link, Albert 2003a) Siegel et al. (2003) cited several environmental and institutional factors that impact productivity noted in prior tech transfer related research studies. They include the amount of economic growth in a state that may be a surrogate for the financial support capabilities of local and regional companies that sponsor university research; and the amount of local firm R&D given that university research leads to local and regional technological spillovers (D. S. Siegel, Waldman, David, Link, Albert 2003a). After studying 122 UK TTOs, Chapple et al. (2005) found that they display low amounts of absolute efficiency and have declining rates of return to scale toward licensing movement (Chapple, 2005). They concluded that these TTOs might need to consider restructuring into smaller entities; and perhaps becoming regional nerve centers with an emphasis on providing assistance to regional businesses and university stakeholders (Chapple, 2005). Likewise, in Europe, to overcome TTO inefficiency, Siegel et al. recommends pooling resources to generate some minimum amount of resources required to maintain efficiency (D. S. Siegel, Veugelers,Reinhilde, Wright, Mike 2007). Further, per Siegel (2007), they should also pay attention to developing a focus on specialty industry sectors. The Chapple research team points out that although in the United States, there are laws such as America's 1980 Bayh Dole Act which mandates the disclosure of faculty researcher's inventions, the UK has no such legal requirement (Chapple, 2005). UK research universities listed in the 2000/2001 Higher Education Statistics Agency publication entitled "Resources of Higher Education Institutions" were sent a survey to collect data (Chapple, 2005). The Chapple team used nearly all of the same internal and exterior environmental factors that the Siegel team using in their 2003 study. However, since nearly all UK universities are public, they did not make a distinction between public and private universities (Chapple, 2005). This research team found that if a region's research and Gross Domestic Product (GDP) are more than other regions, the local universities appeared to be efficient in tech transfer indicating regional spillovers in technology transfer. The Chapple team suggests that the use of regional TTOs might prove to be more efficient (Chapple, 2005).
Availability of Venture Capital	In order to have venture capital available for UK spin outs in the UK, a £ 50 Million pound venture capital fund was established by the government. This University Challenge fund created 12 science-based business centers (M. Wright, Burley, Sue, Mosey, Simon, 2004). It is easy to form spin out businesses. However, it is much more difficult to grow these fledgling businesses into ventures with positive cash flows (M. Wright, Burley, Sue, Mosey, Simon, 2004).

Table 23. Continued. Other University Technology Transfer Resources

	Wright et al. cite the 2004 Heirman research study which identified four (4) different types of start-ups: (1) product start-ups; (2) those backed with venture capital; (3) prospectors; and (4) transitional start-ups which initially commercialize their technical know-how through consulting. Venture capital backed start-ups are a minority and the authors call the others prospectors. Problem areas for prospectors include a lack of clarity of product market (M. Wright, Burley, Sue, Mosey, Simon, 2004).
Corporate sponsored small business development programs	The Wright team identified partnerships with industrial corporations as an external resource (M. Wright, Burley, Sue, Mosey, Simon, 2004) (M. B. Wright, Sue; Mosey, Simon 2004). Other cooperative external resources include the network of science parks. There are important social network links, interactions, networking options, and partnering options between academic entrepreneurs, TTOs and existing corporations which are not well understood (M. Wright, Burley, Sue, Mosey, Simon, 2004) (M. B. Wright, Sue; Mosey, Simon 2004).

APPENDIX E – MODEL IP POLICY

MODEL INTELLECTUAL PROPERTY POLICY

Note: This policy is an edited version of the University of North Texas Health Science Center's (THE UNIVERSITY) Intellectual Property policy. Additional policy statements are included which were motivated by the listing of non-HBCU tech transfer problem areas discovered in the Literature Review. See the Literature Review Summary in Chapter II and pages 143-144 for the discussion. The additional policy statements are <u>double underlined</u>. Text that is recommended to be removed is stricken. References to the University of North Texas, its code sections and Texas Education were removed.

Intellectual Property,
Technology Transfer,
_____ Intellectual Property Policy Equity Development

Policy Statement.
The University of _____ (THE UNIVERSITY) recognizes that Intellectual Property will at times develop from the scholarly activities of administrators, faculty, staff, postdoctoral fellows, interns, residents and students. It is not the policy of THE UNIVERSITY to encourage the development of Intellectual Property at the expense of other scholarly or academic pursuits. However, the institution also recognizes that in some instances, the development of Intellectual Property and the benefits derived from it, monetary revenues, equities and economic activity, are consistent with the goals of the institution and the public good. The goal of THE UNIVERSITY's Intellectual Property Policy is to promote the progress of basic and clinical science and the development of the institution and faculty through the provisions of an established policy. Patents, copyrights, and technology transfer provide a means for developing and using Inventions and Creations. This policy has been developed to ensure that those creative developments in which THE UNIVERSITY holds an interest will be used in a manner most likely to benefit the public, but at the same time, provide benefits to those faculty, staff, postdoctoral fellows, interns, residents, and students who invent and create.

<u>With respect to equity licensing, t</u>he institution recognizes that the benefits and value gained from Inventions and innovations are not limited to direct financial or monetary revenues, but may exist as Equity, options, stock or similar instruments. <u>The institution shall engage in equity licensing as an alternative to seeking cash from institution spin-offs or start-up licensees.</u> It is also recognized that such instruments of Equity may have an intangible value when issued, and the efforts of the Inventors, the institution and licensees may be required to develop value prior to commercialization and marketing. THE UNIVERSITY may desire to participate in such activities to ensure maximized potential benefits to THE UNIVERSITY and THE UNIVERSITY Personnel. This may include the

encouragement of the institution and THE UNIVERSITY Personnel to participate in both Equity and management of businesses that utilize and/or license institutionally developed technology. The institution commits to encouraging a flexible, non-bureaucratic, entrepreneurial supportive academic culture that embraces spin-off and start-up business formations and licensing to spin-offs and start-ups.

Application of Policy.

The Intellectual Property Policy of the University of _____ establishes certain criteria for the guidance of administrators, faculty, staff and students concerning the development, use, ownership, management, and marketing of Intellectual Property as defined herein. The policies that follow shall apply to all persons associated with THE UNIVERSITY, including but not limited to administrators, faculty, staff, postdoctoral fellows, interns, residents, and students, both full- and part-time, both basic science and clinical, and paid or unpaid. These policies apply to, but are not limited to, any scientific and technological development including Inventions, Creations, discoveries, technology, trade secrets, or developments, that arise from the activities of these individuals whether patentable or not, and any works of authorship of these individuals whether copyrighted or not. The review procedures in the Intellectual Property Policy are intended to encourage the broad utilization of the results of research and clinical practice carried out at THE UNIVERSITY, not only by other scholars through free exchange of information and publication, but also in practical application for the benefit of THE UNIVERSITY, administration, the faculty, staff, post-doctoral fellows, interns, residents, students, and the public. By identifying the rights of THE UNIVERSITY, its administration, faculty, staff, post-doctoral fellows, interns, residents, and students, and external research sponsors, the intent of this policy is to enhance (1) the research mission of THE UNIVERSITY, (2) provide rewards to its administrators, faculty, staff, post-doctoral fellows, interns, residents and students who participate in scholarly activity, (3) promote the economic welfare of the State, and (4) protect the traditions of academic freedom and the open dissemination of research findings. This Intellectual Property Policy, as amended, shall be part of the conditions of employment and/or continued employment of all THE UNIVERSITY administrators, faculty, staff, post-doctoral fellows, interns, or residents, and shall be part of the conditions of enrollment and/or continued enrollment of THE UNIVERSITY students. All THE UNIVERSITY Personnel are subject to any changes to this policy made subsequent to employment or enrollment. This policy is subject to amendment by the Board of Regents without prior notice. This document supersedes all previous THE UNIVERSITY Intellectual Property Policy statements.

Definitions.

As used in the Intellectual Property Policy, the following terms have the meanings indicated:

1. **Center** - an authorized Center for Technology Development and Transfer ~~as defined in Texas Education Code Section _____~~.
2. **Creations** - Original works of authorship fixed in any tangible medium of expression.
3. **Creators** - All THE UNIVERSITY Personnel who have authored original works of authorship fixed in any tangible medium of expression.
4. **Disclosure** - A reporting of the existence of an Invention and/or written or recorded Creation to THE UNIVERSITY officials.
5. **Equity** - Shares of corporate, or limited liability business, or partnership, stock, options for such instruments of ownership or similar instruments.
6. **Fund for Development of Intellectual Property,** Venture Capital Fund and Business Incubator.
– An account retaining THE UNIVERSITY's share of revenues from proceeds of Intellectual Property activities. This fund will be used to promote development of Intellectual Property, Venture Capital Fund and Business Incubator and to support appropriate activities of THE TTO.
7. **Intellectual Property** - All Inventions and Creations.
8. **Inventions** - All know-how, trade secrets, innovations, findings, discoveries, computer implemented algorithms, computer hardware, formulations, apparatus, compositions, methods, uses, products, improvements thereof or combinations thereof, whether patented or not, licensed or not at any time under the applicable law as now existing or later amended or supplemented.
9. **Inventor** - THE UNIVERSITY Personnel, who under applicable law, are properly named Inventors of an Invention.
10. **Office of Technology Development and Commercialization (THE TTO)** – THE UNIVERSITY department responsible for the management, protection, and commercial promotion of Intellectual Property, reporting directly to the Vice President of Research.
11. **Originator** - An Inventor and/or Creator.
12. **THE UNIVERSITY Personnel** - All full- and part-time paid and unpaid administrators, faculty, staff, students, post-doctoral fellows, interns or residents.

13. **Intellectual Property Categories for Inventions**
It is clear that several types of Inventions may be attributed to THE UNIVERSITY Personnel. This policy recognizes four such categories and establishes the following guidelines with regard to each:

Category 1 - *Inventions from Independent Work by THE UNIVERSITY Personnel*
Inventions which result from activity by THE UNIVERSITY Personnel which have been performed independently of normal duties, and without any THE UNIVERSITY facilities, resources or support comprise Category 1. A determination by IPAC that an Invention falls in Category 1 indicates that the Originator:

1. received no direct or indirect financial aid from THE UNIVERSITY (other than regular salary);
2. used no facilities or supplies of THE UNIVERSITY; and
3. received no assistance from other THE UNIVERSITY Personnel or students, acting in
the capacities of THE UNIVERSITY Personnel or students.

A determination by IPAC that an Invention falls in Category 1 also indicates that the Invention has not been evaluated, tested, used, or implemented in THE UNIVERSITY facilities including classrooms, laboratories, clinics, and offices.

Category 1 Inventions shall be the property of the individual and THE UNIVERSITY shall claim no property rights thereto. The Originator may offer ownership of the Invention resulting from independent work to THE UNIVERSITY by making a written request to THE TTO, enclosing a copy of the Invention Disclosure and information regarding the stage of protection or commercialization the Invention has reached.

THE TTO will forward the Disclosure to IPAC and consult with IPAC about the Invention. After evaluation of the Invention, IPAC and THE TTO together will make a recommendation to the Vice President of Research as to whether THE UNIVERSITY should accept the offer and attempt to protect and commercialize the Invention. The Originator will be notified of the decision of the Vice President of Research within a reasonable time. Terms and conditions for transfer of ownership to THE UNIVERSITY will be negotiated between THE TTO and the Originator.

An example of a Category 1 Invention is a new and improved bicycle tire invented by a faculty member in biochemistry who happens to be an avid cyclist in his spare time. The work was done in a home workshop and he was assisted by his teenage daughter. No funds or facilities of THE UNIVERSITY were used.

Category 2 - *Inventions from Sponsored Research by THE UNIVERSITY Personnel*
Inventions by THE UNIVERSITY Personnel arising from research sponsored by a non-Health Science Center agency, private or governmental, through an agreement with THE UNIVERSITY, shall be the property of THE UNIVERSITY, subject to other agreement with the sponsor provided that such agreement is consistent with all applicable laws, policies, procedures, and guidelines. This category includes Inventions that arise from research under grants or contracts with:

- agencies of the Government of the United States, or the State of _____;
- non-profit entities;
- for-profit entities; or

- private donors.

In each of these cases, the research shall be carried out under a written grant or contract which states explicitly the rights to Intellectual Property that may result, and which has been reviewed and approved by THE TTO and the Office of Legal Affairs in accordance with THE UNIVERSITY policy.

An example of a Category 2 Invention is a novel compound isolated by a faculty member in biochemistry and discovered to be effective at inhibiting cancer cell growth. The research resulting in the discovery was funded by a NIH grant and experiments were conducted at THE UNIVERSITY using facilities and resources at THE UNIVERSITY.

Category 3 - *Inventions from Research Sponsored by THE UNIVERSITY*
Inventions from Research sponsored by THE UNIVERSITY itself, either directly or indirectly, shall be the property of THE UNIVERSITY. This includes Inventions which might arise from any activity within the regular scope of one's employment, including thesis and dissertation work, as well as special research projects sponsored by THE UNIVERSITY research programs, including intramural research programs, inter-institutional seed grant programs, and programs funded by Intellectual Property revenue. An example of a Category 3 Invention is a novel compound isolated by a faculty member in biochemistry and discovered to be effective at inhibiting cancer cell growth. The research resulting in the discovery was funded by an THE UNIVERSITY intramural research program grant and experiments were conducted at THE UNIVERSITY using facilities and resources at THE UNIVERSITY.

Category 4 - *Inventions from Work Commissioned by THE UNIVERSITY*
Inventions which arise from work commissioned by THE UNIVERSITY and not classified as Category 1, 2 or 3 Inventions shall be exclusively owned by THE UNIVERSITY. THE UNIVERSITY shall have the sole right to determine disposition of the Invention.

14. **Intellectual Property Categories for Creations**
THE UNIVERSITY encourages the preparation and publication of Creations that result from teaching, research, scholarly and artistic endeavors by members of the faculty, staff and student body. Authors shall be permitted maximum freedom with respect to their Creations, consistent with their obligations to THE UNIVERSITY. Creations may be created under a variety of circumstances and conditions which impact the ownership and subsequent management thereof. It is clear that several types of Creations may be attributed to THE UNIVERSITY Personnel. This policy recognizes five such categories and establishes the following guidelines with regard to each:

Category 1 - *Creations from Independent Work by THE UNIVERSITY Personnel*
Creations developed as a result of the individual's efforts on his own time and/or without the use of any THE UNIVERSITY facilities, resources or support and outside the scope of the individual's regular employment with THE UNIVERSITY, are the exclusive property of the Creator and THE UNIVERSITY has no claim to any revenues which may accrue from the commercial disposition of the Creations. A determination by IPAC that a Creation falls in Category 1 indicates that the Creator:

1. received no direct or indirect financial aid from THE UNIVERSITY (other than regular salary),
2. used no facilities or supplies of THE UNIVERSITY, and
3. received no assistance from other THE UNIVERSITY Personnel or students, acting in the capacities of THE UNIVERSITY Personnel or students.

A determination by IPAC that a Creation falls in Category 1 also indicates that the Creation has not been evaluated, tested, used, or implemented in THE UNIVERSITY facilities including classrooms, laboratories, clinics, and offices. An example of a Category 1 Creation is a children's book written by a faculty member during weekends.

Category 2 – *Scholarly works*
In keeping with academic tradition, and except to the extent required by the terms of any funding agreement, THE UNIVERSITY does not claim ownership to pedagogical, scholarly or artistic works created by a faculty member in their capacity as faculty members at THE UNIVERSITY, regardless of their form of expression. Such works include but are not limited to faculty-prepared works such as textbooks, course materials and refereed literature. Such works include those of students created in the course of their education, such as dissertations, papers and journal articles. Creations developed with the intended purpose of disseminating the results of academic, basic or clinical research or other scholarly study, will be exclusively owned by the Creator.

THE UNIVERSITY shall make no claim to any revenues which may accrue from the commercial disposition of Category 2 Creations.

THE UNIVERSITY recognizes and affirms the traditional academic freedom of its faculty and staff to publish pedagogical, scholarly or artistic works without restriction. In keeping with this philosophy, THE UNIVERSITY will not construe the provision of offices, library facilities, or computers as constituting significant use of THE UNIVERSITY resources, except for those instances where the resources were furnished specifically to support the development of such Creations.

Category 3 - *Creations Developed with Significant Use of THE UNIVERSITY Resources*

Creations that are not works for hire but are works that are developed and enabled with integral and significant use of THE UNIVERSITY funds, support personnel, space, hardware, or facilities, where use was essential and substantial rather than incidental, shall be jointly owned by the Creators and THE UNIVERSITY.

Category 4 - *Creations from Work Commissioned by THE UNIVERSITY*
Creations which arise from work commissioned by THE UNIVERSITY and not classified as Category 1, 2 or 3 Creations, will be exclusively owned by THE UNIVERSITY. Regardless of the commercial disposition of the Creation, THE UNIVERSITY will retain a paid-up, royalty free, perpetual, non-exclusive license to use the Creation and all derivative works for academic research and educational purposes. Work Commissioned by THE UNIVERSITY will include work created for institutional purposes in the course of the creators' employment, including but not limited to simultaneous or sequential contributions over time by numerous faculty, staff or students. For instance, work assigned to programmers is Work Commissioned by THE UNIVERSITY or "work for hire" as defined by law, as is software developed for THE UNIVERSITY for THE UNIVERSITY purposes by staff working collaboratively. Brochures, training programs, CD-ROMs, videos, and manuals for which staff members are hired to develop are other examples of Work Commissioned by THE UNIVERSITY, or work for hire.

Category 5 – *Invention Software*
Software for an Invention that is a computer-implemented invention, which Invention is an Invention of **Category 2, 3, or 4,** shall be exclusively owned by THE UNIVERSITY. Regardless of the commercial disposition of the Invention or software, THE UNIVERSITY will retain a paid-up, royalty-free, perpetual, non-exclusive license to use the Invention or software and all derivative works for academic research and educational purposes.

Procedures and Responsibilities.
Procedure / Duty Responsible Party
1. **DISCLOSURE OF INTELLECTUAL PROPERTY**
Before Intellectual Property subject to ownership by THE UNIVERSITY is disclosed to any party outside THE UNIVERSITY, to the public generally, or for commercial purposes, and before publishing same, any Intellectual Property shall be promptly and completely reported by the Originator(s) in writing to THE UNIVERSITY on the form provided by THE UNIVERSITY. The disclosure should be made within a reasonable time, normally within 30 (thirty) days of the discovery or the date the Originator(s) becomes aware of the Invention or completes the Creation, to the Office of Technology Development and Commercialization (THE TTO). If more than one individual participated in the discovery or development, all shall sign the written Disclosure. When received by THE TTO, the written Disclosure shall be recorded in a permanent format and thereafter maintained in the

official records of THE TTO. Disclosures received by THE TTO will be forwarded to the IPAC Chair and membership.

2. **INSTITUTIONAL REVIEW OF INTELLECTUAL PROPERTY**

A. Intellectual Property Advisory Committee (IPAC)

• Organization - IPAC shall be appointed as provided by the Faculty Bylaws of THE UNIVERSITY and shall perform the activities described therein.
• Determinations by IPAC shall make determinations regarding:
• The assignment of Intellectual Property to THE UNIVERSITY under the provisions of this policy;
• The extent to which Intellectual Property was developed by THE UNIVERSITY Personnel or others when performing their duties of employment or through their substantial use of facilities or funds provided by the Institution;
• The response to an Originator's written request of THE UNIVERSITY to release its right to a particular Intellectual Property to the Originator;
• The extent to which more than one individual is entitled to rights in any Intellectual Property;
• The sharing of revenues and Equity participation by the Originator(s) and THE UNIVERSITY; and
• TTHE UNIVERSITY Intellectual Property policy.

IPAC will also provide assistance to THE TTO by THE UNIVERSITY Personnel; THE TTO; Vice President, Research; President; IPAC evaluating Disclosures and making recommendations about technology development and commercialization.

B. Action by IPAC

IPAC shall promptly consider all Disclosures of Intellectual Property and requests for a determination of ownership and rights and shall make a determination in a reasonable amount of time. The Originator is expected to appear before IPAC to briefly describe the Intellectual Property and to answer questions IPAC might have about the Disclosure. Thereafter, IPAC will deliberate and make a requisite determination on the disposition of the Intellectual Property. Written notice of this determination shall be provided to the Originator and copied to the Vice President of Research, and the appropriate department chairman or unit head. Such written notice shall state the findings of IPAC as well as the reasons for its determination.

It is important that the faculty Originator(s) be willing to be continually involved in technology transfer and provide services such as serving as a technical adviser, marketing adviser, or business adviser. The Originator(s) will work closely with THE TTO and any organization to which THE UNIVERSITY assigns rights in pursuing protection for

Intellectual Property, as well as pursuit of marketing by licensing or otherwise. The Originator(s) shall furnish additional information and further records as needed from time to time to facilitate protecting and commercializing Intellectual Property.

The institution encourages a flexible, non-bureaucratic supportive academic culture. In the ~~rare~~ instance where delay would jeopardize obtaining the appropriate protection for the Intellectual Property, THE TTO may, with the approval of the Chairman of IPAC or the Vice President of Research, take appropriate steps to obtain protection prior to IPAC and administrative review. If the request is granted, THE TTO may proceed with the filing of an application to protect the Intellectual Property, pending the routine determinations of IPAC.

C. Appeal of the Determination

If an Originator or other party with an interest in the Intellectual Property, do not agree with the determination of IPAC, they may appeal in writing within thirty (30) days of receiving notification of the determination to the Vice President of Research. The determination of the Vice President of Research will be communicated to the Originator or other party within a reasonable amount of time, generally thirty (30) days.

If an Originator or other party with an interest in the Intellectual Property do not agree with the determination of the Vice President of Research, they may appeal in writing within ten (10) days of receiving notification from the determination of the Vice President of Research, to the President of THE UNIVERSITY. The decision of the President will be communicated to the Originator or other party within a reasonable amount of time, generally thirty (30) days. The President's decision will be final.

D. Responsibility for Authorizing Protection and Commercialization of Intellectual Property

The Vice President of Research, or his/her designee, will be responsible for authorizing protection and commercialization of Intellectual Property owned by THE UNIVERSITY under this policy. Health science related, biotechnology and software technologies will be prioritized over other invention disclosures. All Intellectual Property shall be reported to the Board of Regents in the form of an annual report by THE TTO. Technology commercialization shall be undertaken by THE TTO according to state law and THE UNIVERSITY policies, procedures and guidelines including this Intellectual Property Policy and the Technology Transfer Policy.

The Vice President of Research, or his/her designee, will strive to hire competent TTO staff who are adequately educated and experienced in technology commercialization; and are skilled in marketing, licensing negotiations and business formations. The Vice President of

Research, or his/her designee will strive within budgetary limits to adequately resource the TTO to provide legal budget for patenting, competitive TTO staff compensation,

3. **THE UNIVERSITY Intellectual Property development**

A. General

Having a university and TTO that works to overcome cultural barricades between industry, TTO staff, faculty and patent counsel is imperative. Thus, THE UNIVERSITY's leadership will encourage increased social relationships, networking, relationship building, communication, and engagement between industry, TTO staff, faculty, and patent counsel.

Having a university that seeks increased research funding in the life sciences, chemistry and information technology is very important to the success of university technology transfer. THE UNIVERSITY encourages faculty to spend as much time as possible on grantsmanship. In return, THE UNIVERSITY will provide a revenue sharing incentive to reward the person(s) responsible for the development of the Intellectual Property and their respective departments. In addition, the Vice President for Research will encourage an increase in faculty researcher sizer per program, increased diversity in the faculty pool, and an increase in interdisciplinary research. Further, faculty's patented inventions will count toward tenure and promotion; and release time from teaching will be made available for research. See the section herein entitled "Allocation of University Revenues".

With regard to research results, it shall be mandatory for all employees, academic and nonacademic, to assign the rights to Intellectual Property to THE UNIVERSITY when such Intellectual Property is determined by IPAC to be subject to THE UNIVERSITY ownership. Any written document which reflects ownership will state that THE UNIVERSITY is the owner and assignee of the Intellectual Property and the Originator is the Inventor or Creator. Intellectual Property resulting from research supported by a grant or contract with the federal government, or an agency thereof, with a nonprofit or for profit nongovernmental entity, or by a private gift or grant to THE UNIVERSITY Personnel; THE TTO, President, Office of General Counsel, IPAC, Vice President, Research, Heads of THE UNIVERSITY Departments and Service Centers THE UNIVERSITY shall be subject to ownership by THE UNIVERSITY.

Administrative approval of application requests to, and acceptance of grants or contracts with, the federal government or any agency thereof, with a nonprofit or for profit nongovernmental entity, or a private donor that contain provisions that are inconsistent with this policy, or other policies and guidelines adopted by THE UNIVERSITY from time to time imply a decision that the value to THE UNIVERSITY of receiving the grant or performing the contract outweighs the impact of any nonconforming provisions of the

grant or contract on the Intellectual Property policies and guidelines of THE UNIVERSITY. Employees of THE UNIVERSITY whose Intellectual Property results from a grant or contract with the federal government, or any agency thereof, with a nonprofit or for profit nongovernmental entity, or by private gift to THE UNIVERSITY shall make such assignment of such Intellectual Property as is necessary in each case in order that THE UNIVERSITY may discharge its obligation, expressed or implied, under the particular agreement.

A decision by THE UNIVERSITY to seek patent or other available protection for Intellectual Property shall not obligate THE UNIVERSITY to pursue such protection in all national jurisdictions. THE UNIVERSITY 's decision relating to the geographical scope and duration of such protection shall be final.

The appropriate actions required to manage, protect, promote, commercialize, or otherwise exploit Intellectual Property subject to ownership by THE UNIVERSITY shall be determined and conducted by THE TTO, acting as an authorized Center for Technology Development and Transfer as defined in Code Section _____. As a Center, THE TTO may perform the activities set forth in Code Sections _____in accordance with the Intellectual Property policy, and all other relevant THE UNIVERSITY policies. THE TTO may also engage in activities set forth in Code Sections _____in accordance with THE UNIVERSITY Intellectual Property policy, and all other relevant THE UNIVERSITY policies, provided, however, that institutional ownership interests in such entities established and operated pursuant to Section _____ shall belong to THE UNIVERSITY.

In the event that THE TTO elects not to protect, promote, commercialize, or otherwise exploit Intellectual Property subject to ownership by UNTSHC, the President may elect to release Intellectual Property to its Originator, upon written request of THE TTO by the Originator. Such release will be subject to the following provisions.

1. THE UNIVERSITY shall retain a perpetual, royalty-free license to use the Intellectual Property for research, education, and service purposes.
2. THE UNIVERSITY shall be reimbursed for documented patent and copyright expenses associated with the Intellectual Property.
3. Neither the facilities nor the resources of THE UNIVERSITY may be used to further develop or commercialize the Intellectual Property except as the President may approve where THE UNIVERSITY retains an interest under the terms of the release.
4. THE UNIVERSITY shall receive a share of all proceeds generated from commercialization of the Intellectual Property, the amount of such share to be negotiated by THE TTO and the Originator prior to the time of release.

The University of _____Office of Vice Chancellor and General Counsel will assist THE UNIVERSITY and THE TTO with all legal matters relating to Intellectual Property. On behalf of THE UNIVERSITY and THE TTO, the University System's Office of Vice Chancellor and General Counsel in collaboration with THE UNIVERSITY and THE TTO may enter into contracts for legal services with a competent lawyer or law firm to:

- prepare, file, pursue, and maintain patent applications in the United States or foreign jurisdictions;
- secure copyright protection;
- prepare, file and pursue trademark and service mark applications;
- pursue litigation to prevent or stop infringement of any THE UNIVERSITY Intellectual Property rights; or
- handle any other legal matters related to Intellectual Property.

Such contracts shall be entered into in accordance with the requirements of the University of _____ System Contracts and Agreements Policy and THE UNIVERSITY policy.

B. Revenue Participation

All revenues, other than equity, resulting from the commercialization of Intellectual Property owned by THE UNIVERSITY shall be distributed as follows:

- All appropriately documented patent, copyright,
  and licensing expenditures by THE UNIVERSITY, shall be recovered first. The amount of such recovery shall be determined by THE TTO;
- Intellectual Property resulting from work not commissioned by THE UNIVERSITY: Following the reimbursement of costs, fifty percent (50%) of net proceeds are allocated to the Originator and fifty percent (50%) to THE UNIVERSITY;
- Intellectual Property resulting from work commissioned by THE UNIVERSITY: Following the reimbursement of costs, zero percent (0%) of net proceeds are allocated to the Originator and one hundred percent (100%) to THE UNIVERSITY.
- In cases of multiple Originators, the Originators' share of revenue shall be divided among the Co-Originators in a ratio as they shall mutually agree at the time of executing the formal assignment of the Intellectual Property to THE UNIVERSITY. Should the Originators fail to agree on the proportions of a division, the Originators' share of revenues shall be recommended by IPAC to the Vice President of Research for final approval.

C. Allocation of THE UNIVERSITY Revenues

The allocation of THE UNIVERSITY revenues is intended as an incentive to reward the person(s) responsible for the development of the Intellectual Property and their respective

departments. THE UNIVERSITY's 50% share of net revenues from Intellectual Property resulting from work not commissioned by THE UNIVERSITY will be allocated as follows:

- Forty percent (40%) will be retained and used to promote and develop THE UNIVERSITY Fund for Development of Intellectual Property, Venture Capital Fund and Business Incubator.
- Forty percent (40%) to the Originators' laboratory or research program, provided the Originator is employed at THE UNIVERSITY at the time of revenue allocation;
- Twenty percent (20%) to the Originators' department or service unit.
- THE UNIVERSITY's 100% share of net revenues from Intellectual Property resulting from work commissioned by THE UNIVERSITY will be allocated as follows:
- Twenty percent (20%) will be retained and used to promote THE UNIVERSITY Fund for Development of Intellectual Property, Venture Capital Fund and Business Incubator;
- Eighty percent (80%) to THE UNIVERSITY unit (School, Department, Institute, etc.) that commissioned the work.

In cases of multiple THE UNIVERSITY departments or service units, their share of revenue shall be divided among the departments and/or service units in a ratio as they shall mutually agree at the time of executing formal assignment of the Intellectual Property to THE UNIVERSITY. Should the departments and/or service units fail to agree on the proportions of a division, the share of revenues shall be determined by the Vice President of Research. The decision by the Vice President of Research shall be final.

D. Equity Participation.

In agreements with business entities relating to rights in Intellectual Property owned by THE UNIVERSITY, THE UNIVERSITY may receive Equity interests as partial or total compensation for the rights conveyed. In any such instance, THE UNIVERSITY may elect, at its option, to share an Equity interest with the Originator(s) in the same manner as revenues are shared pursuant to Section 1.104.3.B of this policy. THE UNIVERSITY may also accept Equity interests (Founder's Shares) in a business entity as consideration for THE UNIVERSITY's role in forming the business entity. THE UNIVERSITY shall retain all Founder's Shares received for its activities in the formation of a company. Proceeds from the sale of Founders Shares shall be retained by THE TTO and used to promote THE UNIVERSITY Fund for Development of Intellectual Property, Venture Capital Fund and Business Incubator.

Subject to this policy and other THE UNIVERSITY policies including policies 5.05, 5.06, and the Research Conflict of Interest Policy, employees of THE UNIVERSITY who conceive, create, discover, invent, or develop Intellectual Property may hold an Equity interest in a business entity that has an agreement with THE UNIVERSITY relating to the research, development, licensing, or exploitation of that Intellectual Property. Any equity shared with the Originator as described in this section will be issued, by the purchaser, or licensee, as applicable, in the name of the Originator(s) or THE UNIVERSITY (as separate, definable legal entities).

Dividend income and income from the sale or disposition of Equity interests held by THE UNIVERSITY pursuant to agreements relating to Intellectual Property shall belong to THE UNIVERSITY and shall be distributed as follows:

From Intellectual Property resulting from work not commissioned by THE UNIVERSITY

- Forty percent (40%) will be retained and used to promote THE UNIVERSITY Fund for Development of Intellectual Property, Venture Capital Fund and Business Incubator;
- Forty percent (40%) to the Originators' laboratory, research, or educational program, provided the Originator is employed at THE UNIVERSITY at the time of income allocation;
- Twenty percent (20%) to the Originators' department or service unit;
- From Intellectual Property resulting from work commissioned by THE UNIVERSITY
- Twenty percent (20%) will be retained and used to promote THE UNIVERSITY Fund for Development of Intellectual Property, Venture Capital Fund and Business Incubator;
- Eighty percent (80%) to THE UNIVERSITY unit (School, Department, Institute, etc.) that commissioned the work.

In cases of multiple THE UNIVERSITY departments or service units, their share of equity income shall be divided among the departments and/or service units in a ratio as they shall mutually agree at the time of executing formal assignment of the Intellectual Property to THE UNIVERSITY. Should the departments and/or service units fail to agree on the proportions of a division, the share of equity income shall be determined by the Vice President of Research. The decision by the Vice President of Research shall be final. Dividend income and income from the sale or disposition of an Equity interest (other than Founder's Shares) held by a UNIVERSITY employee pursuant to an agreement between THE UNIVERSITY and a business entity relating to rights in Intellectual Property conceived, created, discovered, invented, or developed by such employee shall belong to the employee. THE UNIVERSITY does not act as a fiduciary for any person concerning Equity or other consideration received under the terms of this policy.

4. **BUSINESS PARTICIPATION**

Subject to THE UNIVERSITY policies, including Human Resources policies 05.505 and 05.506, and the Research Conflict of Interest Policy, as well as applicable state and federal statutes and regulations, THE UNIVERSITY permits business participation to further the development and commercialization of Intellectual Property discovered, developed and/or statutorily protected as the property of THE UNIVERSITY.

Any employee of THE UNIVERSITY who conceives, creates, discovers, invents or develops intellectual property may own or be awarded any amount of equity interest or participation in, or, if approved by the Board of Regents, serve, in his/her individual capacity, as a member of the board of directors or other governing board or as an officer or an employee (other than as a consultant) of, a business entity that has an agreement with THE UNIVERSITY relating to the research, development, licensing, or exploitation of that intellectual property only so long as the employee complies with the following:

- the activity is disclosed in writing to and approved by the President or the President's designee;
- the activity is reviewed and approved by the Conflict of Interest Committee;
- the activity is not a conflict of interest with any THE UNIVERSITY contractual arrangements with any business entity, including any detrimental to the fiscal status of THE UNIVERSITY;
- the employee agrees to report to the Conflict of Interest Committee any potential conflict of interest that arises; and
- the employee agrees to accept the determinations of the Conflict of Interest Committee, which may include terminating the business relationship or the relevant research.

Any employee covered by Section 4 of this policy shall report in writing to the president of THE UNIVERSITY, or to such other person as may be designated by the President, the name of any business entity in which the person has an interest or for which the person serves as a director, officer, or employee and shall be responsible for submitting a revised written report upon any change in THE UNIVERSITY, Personnel, President, Conflict of Interest Committee the interest or position held by such person in such business entity. These reports shall be forwarded to the President by October 1 of each year for filing with the Board or Regents as required by Code Section _____and inclusion in the annual financial report sent to the State officials listed in Code Section _____.

References and Cross-references.
_____Research Conflict of Interest Policy
[List related policies here]

Approved: _____
Effective: _____
Revised:_____

VITA

CLOVIA HAMILTON



Clovia Hamilton was born in Chicago, Illinois in 1966 to parents Cassie Hamilton and Benjamin Franklin Hamilton, Sr. She is the third of four children. She attended George Henry Corliss High, an inner-city public school on Chicago's south side in the historic Pullman neighborhood. This neighborhood was founded by the industrialist and engineer George Pullman. After graduation from high school at the age of 16, Clovia headed down state to Urbana-Champaign, Illinois and earned a Bachelor Degree in Civil Engineering. The University of Illinois at Urbana-Champaign was ranked No. 1 in Civil Engineering worldwide. While in undergraduate school, Clovia worked as a Geology Library Assistant and as a Research Assistant for the US Army Corps of Engineers' Construction Engineering Research Lab (CERL) in Artificial Intelligence Expert Systems Development. Clovia graduated in 1988 and worked for the City of Chicago's Bureau of Construction Management as a road and bridge engineer managing construction contracts. With an interest to learn more about contracting, Clovia began attending law school at DePaul University in Chicago.

In 1990, upon her father's retirement, Ms. Hamilton moved south and joined her parents in Georgia. From 1990 to 1995, Clovia worked for the Georgia Department of Transportation (GDOT) as a road and bridge construction manager, construction materials researcher and transportation planner. She became a certified Associate Public Manager and passed the Engineer in Training (EIT) certification exam in 1993. In 1995, Clovia

began work for the City of Atlanta's Department of Planning and Neighborhood Conservation as the City's transportation planner. By board examination, Clovia became a member of the American Institute of Certified Planners (AICP). Clovia assisted with transportation plans for the 1996 Olympic Games and Atlanta Regional Commission (ARC) transportation-related committee work while attending law school at night. She also worked on the City's Comprehensive Development Plan and Transportation Improvement Program (TIP).

Upon graduation from law school with a Juris Doctorate (JD) from Atlanta's John Marshall Law School, Clovia became a member of the State Bar of Georgia. With an interest in technological innovations, Clovia relocated to the Washington, DC area to work for the US Patent and Trademark Office (USPTO). She completed their patent examination training and served as a mechanical patent examiner of construction and transportation related wheeled vehicles. Next, Clovia worked as an Environmental/ Mechanical Engineer and Technology Transfer Specialist for the US Environmental Protection Agency (EPA)'s National Vehicle and Fuel Emissions Lab (NVFEL) in Ann Arbor, Michigan. In 2000, Clovia passed the daunting Patent Bar examination and became a registered patent attorney.

In 2000, Ms. Hamilton relocated back to Illinois and served as a Technology Transfer Specialist for the University of Illinois in Urbana-Champaign's Office of Research. Clovia managed the College of Engineering's patent portfolio and earned a Master of Laws (LLM) degree in Intellectual Property Law. She then accepted a promotional career opportunity at Old Dominion University in Norfolk, Virginia where she served as the Director of Intellectual Property and Research Compliance. Clovia served on the Sponsored Programs Manager Search Committee, an Engineering Management Assistant Professor Search Committee, the Institutional Review Board (IRB) as the University's Human Protections Administrator, Institutional Animal Care and Use Committee (IACUC) as a Non-Voting Member, Patent and Copyright Committee as an Ex officio member, the Radiation Safety Committee as a Member, and as the Research Integrity Officer. Clovia

was also an invited speaker for the Virginia Joint Commission on Technology and Science and delivered the speech *Developing ODU's Intellectual Property Infrastructure.* In addition, she was also an invited moderator and speaker for the Association of University Technology Managers' (AUTM) International Annual Conferences in 2003 and 2004 and participated in a group presentation entitled *How to Operate a Small Technology Transfer Office.*

With an interest in research and business integrity, Ms. Hamilton began to teach business law and ethics as an Adjunct Professor. Since 2005, Clovia has taught undergraduate and graduate students online and on the ground for Clark Atlanta University, Mercer University, Strayer University, Park University and Atlanta Metropolitan State College. Her teaching philosophy is to encourage students to analyze and discuss real world ethical dilemmas including the ones they have experienced or observed in their workplaces or in current events. Clovia believes in encouraging students to improve their critical thinking, research and writing. They are required to complete writing assignments, distinguish between facts and opinions, participate in team debates, and participate in group project papers and presentations. She also makes the course content interesting with the use of videos.

With a desire to teach and conduct research, Clovia relocated to Greenville, North Carolina and served as an Assistant Professor of Urban Planning at East Carolina University. She taught planning law and served as the Prelaw Advisory Committee Chair and Faculty Adviser to the Phi Alpha Delta Law Fraternity Prelaw Chapter. She also worked with the Provost to create a JD in 6 program. Clovia served as a member on the College of Technology and Computer Science's Strategic Planning Committee; and as the Chancellor's Representative on the Research and Creative Activities Committee reviewing and ranking 71 proposals for funding in the Fall of 2003. In addition, Clovia was a Work Team Member in the Hallmarks of Excellence for First Year Students program.

Clovia's published research includes: the *Adequacy of the 1995 Antitrust Guidelines for the Licensing of Intellectual Property in Complex High-Tech Markets* (7 Comp. L. Rev. & Tech. J. 23, Fall 2002); *University Technology Transfer and Economic Development: Proposed Cooperative Economic Development Agreements under the Bayh-Dole Act* (36 J. Marshall L. Rev. 397, Winter 2003); *High -Tech Transportation Corridors are in Vogue: Proposed Federal Transportation Policy Amendments* (14 Albany L. J. Sci. & Tech. 2, Spring 2004); and the peer reviewed *Adequacy of the 1995 Antitrust Guidelines for IP Licensing: Commentaries from the 2002 FTC and DOJ Hearings about the Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy* (7 J. Internet L. 7, January 2004). Clovia has 20 citations so far.

In 2005, after returning to Georgia to live closer to her family, with an energetic, entrepreneurial spirit, Ms. Hamilton founded Lemongrass Consulting while working as an engineer for the City of Atlanta's Site Development Department. Lemongrass Consulting's clients included Florida A&M University (FAMU) Office of Research, AL State University Small Business Development Center (SBDC), Clayton State University's Continuing Education Department, Atlanta Metro State College's Entrepreneurship Center, DeKalb County Workforce Development Center, the Atlanta Technical College and Roy Mitchell's Permitting Services. Lemongrass Consulting provided business, workforce, research and community development services. In 2008, Clovia received a Sam Walton Emerging Entrepreneur Award.

Clovia learned government contracting as a student and client of Georgia Tech's DOD funded Procurement Technical Assistance Center (PTAC). She excelled and began to work for Georgia Tech full time as a Program Manager and Procurement Counselor servicing southwest Georgia. Clovia served as a small business counselor and taught government contracting for Georgia Tech from 2009-2012. Her productivity was 1200% of goal. Clovia taught 1-3 hour long seminars entitled *Business Planning*, *Development and Management*, *Business Financing*, *Surety Bonding*, the *Fundamentals of Working with the*

Government, *Introduction to Government Contracting*, *Preparing Successful Bids and Proposals*, *Marketing to the Government*, *General Services Administration (GSA) Schedule Contracting* and *Subcontracting to Primes*. Using her entrepreneurial skills, Ms. Hamilton secured technical assistance contracts for Georgia Tech to manage the City of Albany and Dougherty County's Small Business Development Programs ($125,000 and $55,000 respectively) and served on the City of Albany, Georgia's Microbusiness Enterprise Center Advisory Board. Clovia also designed and managed a large Speed Partnering event at the Albany Civic Center for hundreds of government contractors and government agencies in the region.

With a desire to learn more about business management, Ms. Hamilton earned her MBA at Wesleyan College in 2014. While in the program, she was awarded a $12,000 cash Career Development Grant from the American Association of University Women (AAUW) and a Women in Public Policy (WIPP) Emerging Leader Award. Clovia completed an exciting study abroad in Dubai, UAE and Rome, Italy. Thereafter, in 2014 and with grooming from The PhD Project, Clovia began work on her PhD in Industrial & Systems Engineering with a concentration in Engineering Management at the University of Tennessee in 2014. Clovia has served as a Graduate Research and Teaching Assistant for the University of Tennessee Knoxville and Space Institute. She taught Engineering Law and Ethics for the Space Institute as an online Lecturer in the Summer of 2015 and helped the Knoxville campus with Introduction to Engineering Statistics courses.

Clovia also serves as a Board Member to the Association of Engineering Managers (ASEM) in the capacity of Legal Adviser; a Peer Reviewer for the Babson Entrepreneurial Research Conference, American Society of Engineering Education (ASEE), and the Academy of Management (AOM); and as a member and scholarship essay reviewer for the George Pullman Foundation's Scholarship Alumni Selection Committee. Clovia is also a member of the Institute of Industrial & Systems Engineers (IISE), Society of Business Ethics (SBE), American Association of University Women (AAUW), Association of

University Tech Managers (AUTM), Society of Women Engineers (SWE), and the Women in Public Policy (WIPP). In 2015, Clovia presented *University Tech Transfer from the Attention Based View* at the ASEM IAC Conference in Indianapolis, Indiana which is a peer-reviewed published conference proceeding; and *A Meta-Analysis of University Technology Transfer* at the Babson College Entrepreneurship Research Conference in Boston, Massachusetts.

As you can surmise, Clovia Hamilton is a highly productive team player! Her research is focused on university and federal lab technology transfer, industry partnerships, entrepreneurship, and business ethics. She conducts inter-disciplinary research and has been working with Dr. David Schumann, Emeritus Professor of Marketing at the University of Tennessee Knoxville on job insecurity research. They have the following publication forthcoming in October 2016: Hamilton, C., Schumann, D. (2016). Love and Hate in University Technology Transfer. In M. H. Schwartz, Howard (Ed.), *The Contribution of Love and Hate to Organizational Ethics* (Vol. 16): Research in Ethical Issues in Organizations Series. Emerald Group Publishing.

Ms. Hamilton desires to return to the Academy to earn tenure. She plans to publish the content of her PhD dissertation entitled *A Tool Kit for Building HBCU Technology Transfer Supply Chain Networks using an Advanced Planning System* and to make many more scholarly contributions for many years to come. She would like to rise through the ranks from Assistant Professor to Associate Professor to Full Professor to Department Chair, Dean, and retire from serving as a Vice President for Research. Her goal is to learn by doing. For work-life balance, Clovia enjoys spending time with her 25 year old son Julian Hamilton who serves in the US Air Force, her 15 year old daughter Chloe Hamilton, and friends. Clovia is active in social media networking and her hobbies include cooking, sewing, billiards, gardening, traveling, thrifting, and taking long walks.