University technology transfer office success factors: a comparative case study

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Abstract: This study reviews the literature involving critical factors contributing to university technology transfer office success and then examines those factors within a stratified sample of four comparative case studies of peer university technology transfer offices. Two models of relative success and failure emerged, based on similarities and differences along the eight factors identified in the literature. Two additional success factors emerged during the course of the research. The ways in which technology transfer offices organised the commercialisation process, along with the degree of focus on both internal and external website utility, also seemed to play a significant role in university technology transfer office success.

Keywords: university technology transfer; critical success factors; university research commercialisation; technology transfer websites; organisation structure; technology transfer offices; technology commercialisation structure; technology management.

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1 Introduction

In the quest for global competitive advantage and increased standards of living, government policies have sought to enhance competitiveness by investing public funding into basic research and early stage product development at universities and research institutes to enhance investment readiness (Moore, 2002), as well as increase entrepreneurial activity and spur economic growth (Shane, 2002). Thus, translating basic technology advances into commercial innovations is a central feature of a knowledge-based economy- and technology-transfer offices (TTOs) are central agents in managing publicly funded academic inventions into commercially valuable product innovations.

The technology transfer literature provides a variety of objectives that managers in charge of the university technology commercialisation process may adopt (Thursby et al., 2001), ranging from relatively concrete and short-term objectives such as patent filing and maintenance, commercialising and marketing technologies, and awareness building (Horng and Hsueh, 2005) to longer term and more abstract objectives such as research faculty retention, closer university-industry links, enhanced university prestige, and the acceleration of technology transfer primarily for social and economic benefits (Feldman and Desrochers, 2003; Siegel et al., 2007). As a result, the way that universities organise, set goals and measure their successes tend to differ widely, based on which subset of objectives they emphasise. Additionally, while specific features of the university technology transfer offices have been identified (Siegel et al., 2007; Smilor and Matthews, 2004), as yet, no study has attempted to systematically categorise these features and combine them into models of success or failure.

This paper describes a research project involving semi-structured interviews and surveys of four peer university technology transfer offices in order to better understand how US universities organise and conduct technology commercialisation and which configurations seem to lead to success. Current literature on the university technology transfer process was used to identify potential success factors as well as to compare and evaluate the strengths and weaknesses of each of the four institutions studied. To supplement the case study data, we also collected peer data from the Association of University Technology Managers (AUTM) and content-analysed 48 university technology transfer websites. The study resulted in two general technology transfer models, one successful and one less so.

At least one caveat is in order: clearly, these models cannot be divorced from the institutional, temporal, and geographical contexts in which they exist. Thus, for

universities considering adopting a specific model, the 'fit' of that model for their stage of development, as well as their existing culture, environment, and location, must be considered. However, these descriptive and comparative case studies should provide some guidance to both existing university technology transfer offices that are not satisfied with the performance of their existing operations, as well as for those universities in early stages of organising their technology commercialisation activities.

2 Critical success factors of technology transfer offices

While successful commercialisation and transfer of university-based research has been a recent focus of attention in the academic literature (including Yencken, 2008; Smilor and Matthews, 2004; Churchill et al., 2009; Meseri and Maital, 2001) and others have identified as important the role played by university technology transfer offices (Siegel et al., 2007), no study to date has systematically compared successful and less successful TTOs to determine the factors that lead to university technology transfer *office* success. In this section, we review the literature regarding eight of those factors: business strategy and marketing, intellectual property protection, performance benchmarking, revenue generation focus, institutional prestige, business stakeholder relationships, alignment of institutional interests, and institutional support.

2.1 Business strategy and marketing

While the topics of strategy and marketing have been researched extensively in the business and management literature, few studies are available which look at either topic in the context of university technology transfer office policies. This gap in the literature is unfortunate, as research by Parker and Mainelli (2001), based on an anecdotal review of 100 failed technology commercialisation projects, concluded that 97% of the failures were managerial in nature, with only 3% resulting from 'poor' science. They identified five 'great mistakes' often made, mostly involving non-existent or faulty business strategy. These include:

1 assuming that features will be benefits

2 using top-down market analysis

3 avoiding the 'chicken gun test' (an expected risk assessment tool)

4 failing to put someone in charge

5 not valuing a new technology fully.

Additionally, results from a study of successful technology transfer within the manufacturing industry by Zahra and Nielsen (2002) stressed the importance of speed to market in gaining a competitive advantage. They found that keeping as many key functions in-house (as opposed to outsourcing) and formally coordinating sources within the organisation promoted commercialisation. Because keeping functions in-house in a university setting means locating them within the technology transfer office, these observations are relevant to our study.

2.2 Intellectual property protection

From an extensive study of MIT's patenting processes from 1980–1996, during which time 1,397 technologies were patented and 717 licensed, Shane (2002) made the following observations regarding intellectual property protection:

1 licensing is more likely when a patent is effectively protected

2 the effectiveness of a patent increases royalties for inventions licensed to non-inventors

3 half of all university patents are never licensed.

He also discovered a pattern to this last point: if a patent offers a strong competitive advantage, meaning that it provides effective exclusivity such that others cannot 'invent around it', then that patent it is more likely to be licensed (e.g., Shmuel Cabilly's family of patents covering the "fundamental technology required for the artificial synthesis of antibody molecules" was originally filed in 1983 and licensed by Medimmune. The patent estate has withstood multiple challenges by companies including Genentech which unsuccessfully pursued it to the US Supreme Court in 2007, resulting in annual licensing fees of over $125 million on products like Herceptin® and Rituxan®). One recommendation he makes to strengthen the institution's patent position is to have specific rules on information disclosure about intellectual property, presumably generated and enforced by the university's technology transfer office. Parker and Mainelli (2001) address a related licensing issue, suggesting that spin-offs often make a huge mistake when they do not own outright (vs. licence) the intellectual property on which their business is based. On the other hand, ownership is often not available compared to exclusive licences because technology transfer offices want to ensure that technologies are fully exploited on a timely basis and have 'claw-back' rights in the event of firm failure.

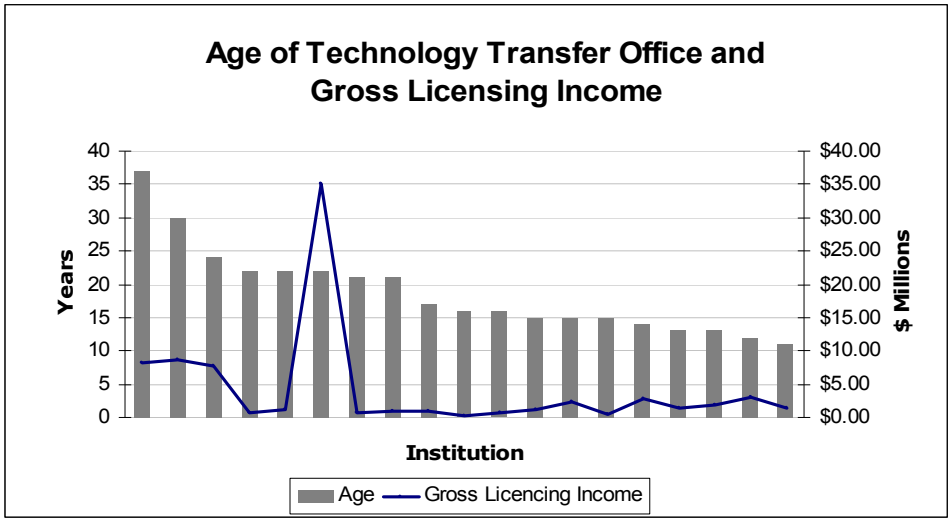
2.3 Performance benchmarking

Limited research exists on performance measurement of university technology transfer offices, although benchmarking performance is a central theme in strategic management and project management. In the strategy field, organisational performance benchmarks typically have two reference dimensions: internal trend analysis and external competitor analysis (Ruth and York, 2004). Trend analysis by nature is longitudinal, in the sense that an organisation's current performance is compared with past performance, while competitor analysis can be either longitudinal or cross-sectional. An additional measure often used by firms to benchmark internal performance is to track target performance goals (e.g., budget) versus accomplishments (e.g., actual results). Further, since each discrete technology may be seen as an individual project, the project management literature is also a useful framework in considering TTO activities. Project management experts offer various technology selection models which broadly fit into two approaches: financial models and strategic alignment (Rad and Levin, 2006).

From an internal performance benchmarking perspective, Parker and Mainelli (2001) stress the value of reducing uncertainty through the use of 'staged gateways', which involves using specific milestones and rigorous evaluation of an invention at key points in its development. They suggest that funding should be granted incrementally at each

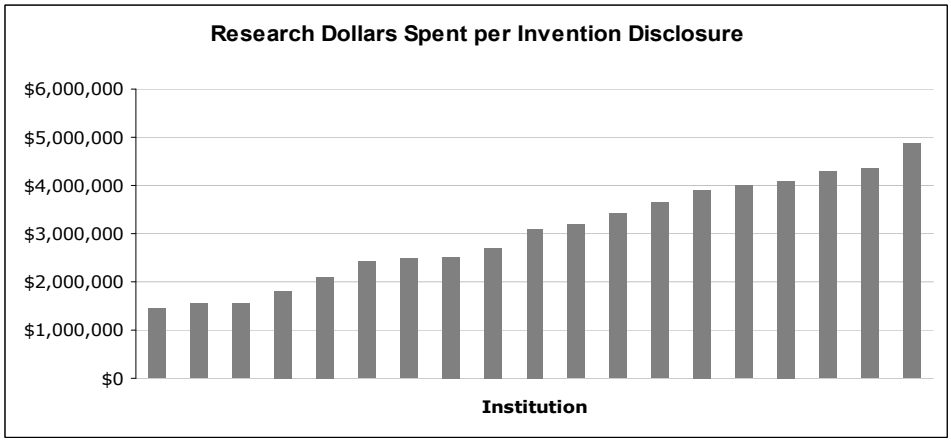
stage of accomplishment, a process that, over the long-term, reduces both uncertainty and cost. This process of managing funding on the basis of contingency and performance may be thought of as a real options framework (Trigeorgis, 1996), which is sequentially dependent upon continued progress to advance or subject to discontinuation at each stage. External benchmarking data has been available for peer institutions since AUTM began to collect performance and demographic data in 1991. Figures 1–4 provide examples of the types of information available from this source. Based on our analysis of nineteen peer institutions that were included in the 2003 AUTM data, several key points seem worth noting.

Figure 1 Age of the technology transfer office and gross licensing income (see online version for colours)



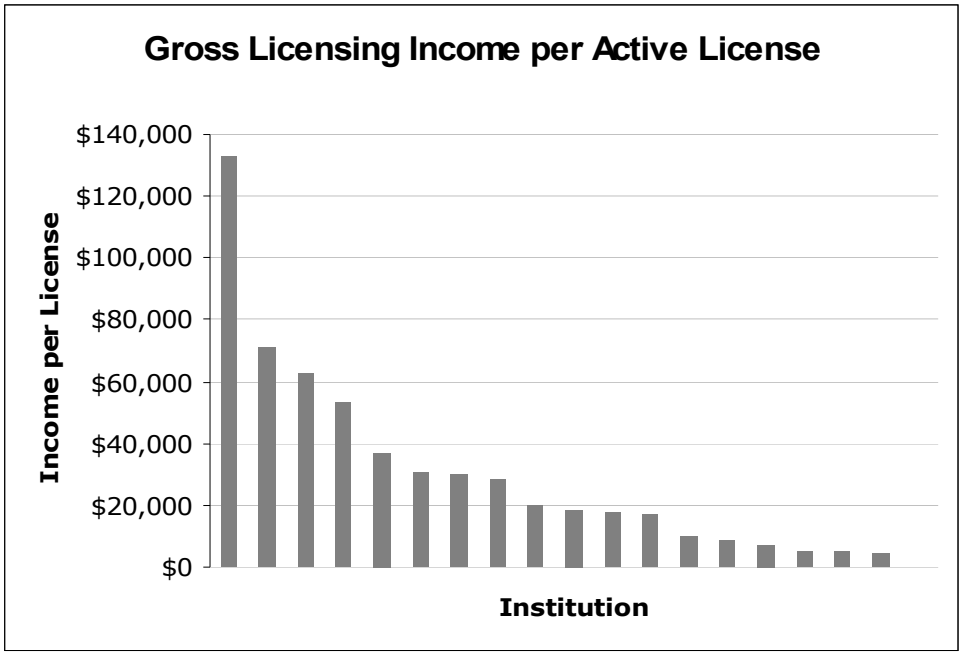
Note: Data from the 2003 AUTM Survey was used to produce this figure.

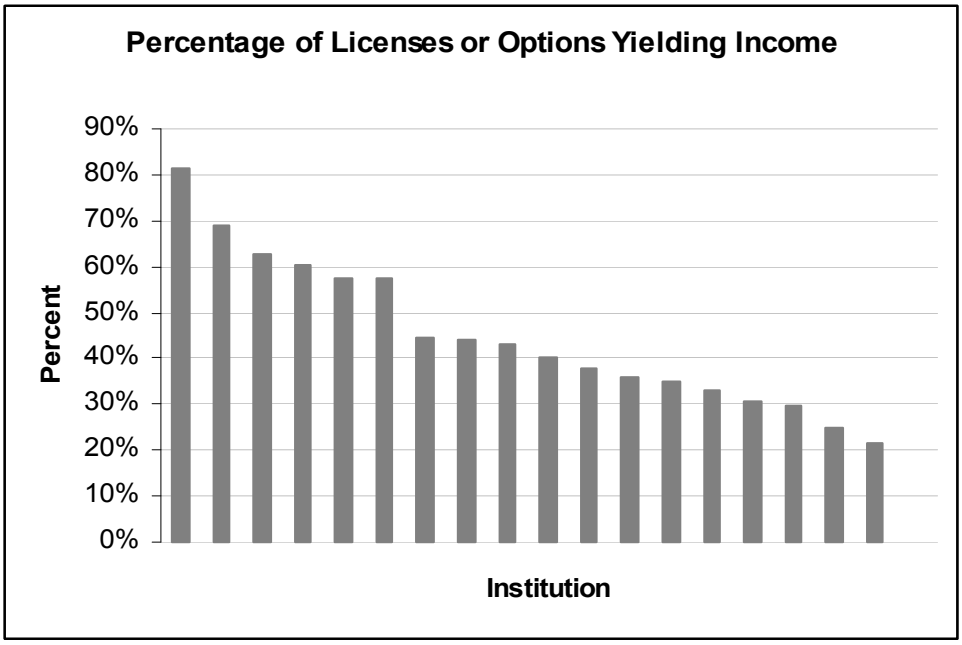
Figure 2 Research dollars spent per invention disclosure



Note: Data from the 2003 AUTM Survey was used to produce this figure.

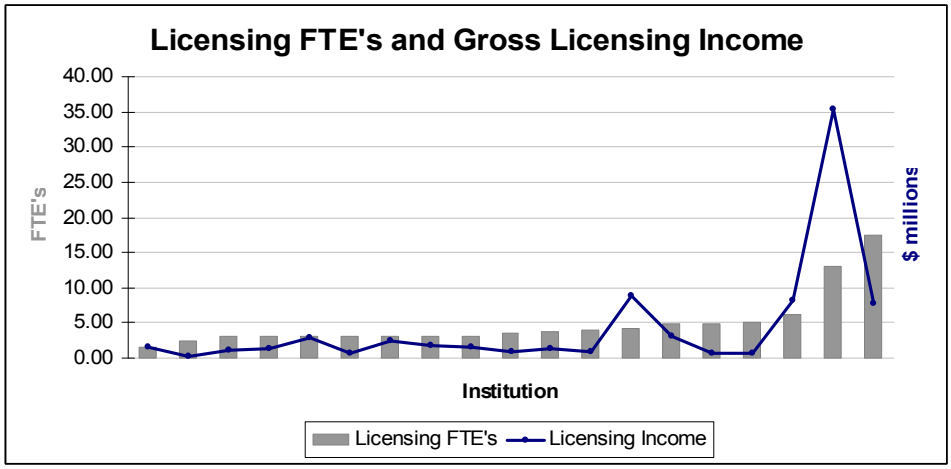
Figure 3 Gross licensing income per active licence and percentage of licences or options yielding income





Note: Data from the 2003 AUTM Survey was used to produce these figures.

Figure 4 Licensing FTE's and gross licensing income (see online version for colours)



Notes: Data from the 2003 AUTM Survey was used to produce this figure.

Figure 5 University of Colorado internal benchmarking data (see online version for colours)

Technology Transfer Key Performance Indicators

Item/metric	Targets 04/05	Accomplishments	Targets 05/06
Inventions reported to TTO	169	177	15% increase
Patent applications (US Filings)	115	139	15% increase
Licensing transactions (options and licenses)	47	59	15% increase
Ratio of legal fee reimbursements to legal expenditures	42%	42%	48%
Royalty revenue[1]	$5.2M	$21.7M	15% increase
Start-up companies	12	9	10
IP induced sponsored research	$4.5M [2]	$4.7M	$5M
Executed Service Agreements	569	574 [3]	15% increase

(1) Does not include revenue derived from legal settlements that in Fiscal Year 2004 amounted to $28.1M and in Fiscal Year 2005 amounted to $6.7M.
(2) Conforms to the Association of University Technology Managers (AUTM) definition
(3) Service measure includes material transfer agreements, confidential disclosure, faculty consulting, software evaluation, and interinstitutional and IP agreements.

Founded in 1876 with a campus in Boulder, the University of Colorado includes three unique campuses offering more than 300 degree programs. The combined fall 2004 enrollment of the Boulder, Colorado Springs, and Denver and Health Sciences Center campuses was 52,448 (38,535 undergraduate and 13,913 graduate), including 41,470 (79%) resident students.

Nomenclature used throughout this report refers to the fact that, as of July 2004, the previous two campuses in Denver and Health Sciences Center administratively merged into one.

First, a university technology transfer office's licensing productivity seems only loosely related to its age. Institutions also vary significantly in what might be termed research efficiency, computed as the ratio of invention disclosures to funded research dollars. The licensing efficiency (the ratio of licensing revenue to number of active licences) data suggest that while, on average, university licences earn impressive revenues, the variability of licensing revenue is high, with most licences earning no revenue. In

addition, there is a wide variability in licensing revenue earned per full-time licensing employee (FTE), suggesting that some technology transfer offices elicit greater productivity from their professional staff than others, although the reasons behind these differences have not yet been empirically explored.

The University of Colorado's technology transfer website (2005) provides examples of how both trend and competitor performance can be transparently tracked. Figure 5 shows performance dimensions internally benchmarked, along with target goals, performance against those goals for the 2004–2005 year, and revised goals for 2006. The Colorado system sets forth a method of tracking performance trends over time, using the 2004–2005 academic year as the reference point. Table 1 shows how the University of Colorado performed versus against eight external peer institutions identified in 2000 in terms of some of the same internal measures tracked over time. This external information obviously is not comparable to the internal information reported above due to the differing time frames, as well as absolute versus standardised measures of reporting. Nevertheless, it does provide an example of cross-sectional, external performance benchmarking and the potential merits of collecting and analysing such data.

Table 1 CU peer university comparison data

CU – peer university comparison (all figures per $10 million federal sponsored research)				
	Colorado (2000)	*Colorado Four year trend*	*8 Peers (2000)*	*8 Peers Four year trend*
Professional staff	.2	Steady decline	.5	Gradual, slight increase
Invention disclosures	3.1	Steady decline	7.1	No growth
Patents awarded	1.0	Steady decline	1.8	Gradual, slight increase
Licences granted	.6	Gradual, slight decline	2.8	Gradual, slight increase
Licence income	$74,000*	Steady decline	$424,000	Steady increase

Note: *This table is estimated to be at least double, but because of prior licensing arrangements, not all CU licensing revenue is reported through the central administration.

2.4 Revenue generation focus

A key question facing technology transfer offices is how to set revenue and valuation goals for spinouts, startups and licensing and how to structure those transactions. University startups and spinouts, which are revenue alternatives to licensing, have several potential advantages, including increased long-run returns to the institution, enhanced economic development, enhanced faculty and university reputations, and inventor retention (Feldman et al., 2002). However, one key downside of startups and spinouts is the lack of market expertise and infrastructure needed to be successful, which reduces the probability of commercialisation, as well as high turnover rate of scientific founders. Gunsalus (1989) describes a systematic way for university administrators to determine the best course of action with respect to licensing to inventors pursuing spin-offs or startups based on the inventor's relationship with the university and whether the university takes an equity position in the venture.

Shane's (2002) transaction costs-based study of MIT's patenting and licensing processes draws several conclusions regarding licensing:

1 university technology tends to be licensed to non-inventors

2 licensing back to the inventor increases the likelihood of licence termination and decreases likelihood of technology commercialisation.

As a result, he suggests a licensing 'rule of thumb'. If a patent is effective, licence the technology to non-inventors. However, if the patent does not provide effective exclusivity, licence it to the inventor. Because non-inventors have the appropriate resources and experience to commercialise a new technology, licensing an effective patent to them yields a greater return. Likewise, transaction costs dictate that licensing to an inventor when the patent is weak is the better option because inventors already possess the necessary knowledge and it is not necessary to risk disclosing the new technology to an outsider. Shane (2002) also recommends that licensing contracts include consulting agreements with, and royalty payments to, the inventor(s); that both the institution and inventor have equity investments in the venture; and that the institution should include technology licensing policies as part of their strategic plan.

2.5 Institutional prestige

In a 2003 study, Sine et al. reported a link between institutional prestige and the number of licensing agreements made by universities. In this research, prestige was a greater predictor of licensing success than previous licensing activity. Using the term 'halo effect' to describe the magnifying effect of prestige, Shane measured prestige in three ways: graduate school ranking in *US News and World Report*, inclusion in *The Gourman Report*, and graduate department ranking by the 1992 National Research Council (NRC). He suggests that the trend toward strategic alliances between universities and industry may be another effective way to increase the 'halo' created by institutional prestige. Further, Kumaramangalam (2005) found that higher academic status and collaboration conferred tangible value to entrepreneurial companies. While there is little that can be done by university TTOs to directly influence university prestige, clearly this factor can affect their office's performance, due to the greater desire among licensees to do business with prestigious universities.

2.6 Business stakeholder relationships

While the literature reviewed thus far suggests three major stakeholders in the university technology transfer process – researchers, technology transfer offices, and entrepreneurs and managers – little emphasis has been placed on the positioning of technology commercialisation within the broader business ecosystem in which it exists. Elmuti et al. (2005) focus on this issue in their study of corporate and university alliances, reporting that the number of strategic alliances between these two entities has grown 20% every year since 1987. MIT, for example, has large scale, multi-year, multi-programme alliances with eight corporations including Merck, HP, and Microsoft. Other examples include Texas Tech and Raytheon, Co. and the Software Quality Institute at University of Texas at Austin, which includes 28 representatives from both industry and government. Such alliances help businesses face global competition, as well as meet the rising demand for innovation, research funding and development, technology transfer (Elmuti et al., 2005). They also provide the funding for commercialisation often not available within the

academic setting (Wright et al., 2004). Studies have also shown (Shane and Stuart, 2002; Hsu, 2004) that the relationships between venture founders and venture investors are strong predictors of initial venture funding, survival, and likelihood of eventual exit such as an initial public offering (IPO) or trade sale. Thus, the external networks of university technology transfer officers are likely to play a role in their office's success.

2.7 Alignment of institutional interests

The technology transfer process basically involves three groups: '*disseminators*' who are university technology transfer office managers and administrators, '*adopter-firms*' that commercialise the new invention, and '*developers'* who are university scientists who make discoveries in their research. These three groups often have differing goals which must somehow be aligned.

According to Boni and Emerson (2003), Carnegie Mellon University made changes in their technology transfer policies in 2001 to improve institutional alignment issues. They report that before changing their policies, there was a sense of opposition rather than enthusiasm between the university and its inventors. Because the university's mission was to benefit society, they decided that technology commercialisation should be offered as a service to faculty, staff and students. They also sought to make the process simple, clear, fair and fast. The following policy changes resulted:

1 proceeds from innovations are shared by all creators, whether or not they have faculty status

2 the university dropped its equity percentage in spin-off companies and decreased its licensing percentages from 15% to 5%

3 proceeds earned by the technology transfer office are used to pay for core services of a programme which stimulates an innovative culture across the campus (this third change was modelled after Stanford University's policies).

2.8 Institutional support

Boni and Emerson (2003) also address the need for top-down support from university administrators, suggesting that such support is vital to success in technology transfer office success. Without top-down support, it is difficult to gain the financial and cultural support necessary to operate a successful technology transfer office. They recommend two indirect options for garnering administrative support if the direct approach of having an administrative champion(s) has failed. First, strong senior faculty that have an interest in technology transfer may serve as 'faculty champions' and thus can exert their influence on their peers to discuss the prioritisation of technology transfer with the administration. A second possibility is to build rapport with the business community by defining how university technology transfer can benefit them. An informed business community can then exert significant influence directly on the university administration to prioritise technology transfer, or they can mobilise state legislators who, in turn, can influence university administrators to make technology transfer a priority.

While not all-inclusive, the eight categories identified in the research reviewed above provided a general framework for collecting information for the four case studies described later in this paper.

3 Methodology

Because our research project began without developed theory and a series of fragmented empirical studies regarding the success and failure of university technology transfer offices, in this study we used a combination of methods, part deductive, based on existing theoretical and empirical literature reviewed above, and part-inductive, based on semi-structured interviews with four institutional technology transfer offices. We also supplemented these two sources with AUTM data and relevant information from websites of 48 US institutions with technology transfer offices. Please see Appendix 1 for the questions used in the interviews and Appendix 2 for a list of the institutional websites analysed. The two models that emerged are built around the practices of the four institutions studied in depth; information from the other sources did not contradict, but rather enriched, these case-based models.

3.1 Sample selection

To select the sample institutions for our in-depth interviews, we began with the technology transfer office of a Midwest university that approached us with an interest in improving its operations and then selected, with their input and that of other technology transfer experts, three of that university's identified 'peer' institutions that were further advanced on the technology transfer learning curve, two of whom had made significant changes in recent years. All of these universities were located in the middle part of the USA (Midwest and Rocky Mountain regions). We purposefully selected one poorly performing institution, one high performing institution, and the two that were undergoing changes, one more successfully than the other, in order to construct a stratified sample that gave us a chance to look at performance variation as well as differences along the eight success factors identified in the literature. All of the sample organisations were located within public universities.

3.2 Semi-structured interviews and other data analysis

To analyse our interview notes, we took the approach used for qualitative inductive data analysis suggested by Eisenhardt (1989), Glaser and Strauss (1967), Lee (1999), Miles and Huberman (1984), and Yin (2009). Using an inductive approach, we were able to develop a richer and more integrated framework with new insights and theoretical propositions (Eisenhardt, 1989; Yin, 2009). We began with a literature review that provided the framework for developing the open-ended interview questionnaire. Two MBA students first conducted the interviews with university technology transfer office personnel, who were promised that the information provided, would be sanitised in order for them to speak frankly and for the sake of confidentiality. Then, two additional MBA students collected relevant AUTM peer institution data and information from 48 institutional technology transfer websites. The data analysis process consisted of an iterative approach which involved going back and forth between our semi-structured interview data, website content, existing literature and theory, and emerging concepts to synthesise the data and develop two models and related propositions. We started by comparing the responses of the four institutions on the success factor dimensions identified in our literature review. We then added details from the interview transcripts that did not fit into these pre-specified categories but which seemed pertinent to the

research question. Next, we organised these key thoughts into tables and matrices to compare and identify emergent patterns and dimensions across the four cases. This process not only revealed factors that coincided with our expectations, but also suggested several factors that had not been explored in previous literature. Several common beliefs in the technology transfer industry were called into question as well. The results of this analysis are reported in the following section.

4 Case study results

This section provides an in-depth analysis of four university technology transfer offices on the categories identified in the literature review above as key success factors, along with some demographic information on organisational age and size. These factors include business and marketing strategy, intellectual property protection, performance benchmarking, revenue generation focus, business stakeholder relationships, and institutional support. Each case study was based on the institution's responses to nine open-ended questions designed to elicit desired information and selectively enriched with information obtained from our analysis of 48 institutional technology transfer websites and the 2003 ATUM peer institution data. Two categories identified in the literature review were not explored in the case studies; we discuss reasons for this later in the article. We also added two new categories based on issues that emerged during our research: project structure and internal and external website utility. Finally, we also identified several issues and extensions for further research.

In the sections below, we compare and contrast each institution across these eight identified dimensions. Please note that each institution has been given a code name to protect its identity and to ensure confidentiality but also to signal the nature of their adopted business model. In this nomenclature, 'Veteran' is used to denote the oldest and most successful office. 'Phoenix' is an institution which in recent years has transformed itself and has shown early success with the changes. 'Transition' is an institution in the process of changing, but definitive performance improvement as result of new policies remains unclear in terms of changing the trajectory of the institution's success. The last institution, 'Step-Child', is an organisation that has languished due to inattention from university administration and red-tape from, and territorial disputes within, the broader university system.

4.1 Age and size

The technology transfer literature tends to divide institutional programmes into pre- and post- the 1980 Bayh-Dole Act (Mowery and Sampat, 2005), which gave universities ownership of their intellectual property from federally funded research and resulted in the establishment of most technology transfer offices. One of our institutions, 'Veteran', was pre-Bayh-Dole, while three, 'Transition', 'Phoenix', and 'Step Child', were post. Older institutional programmes have a clear advantage in terms of stakeholder relationships and several other categories, which are discussed in more detail below. At the time of the study, 'Transition', 'Phoenix', and 'Veteran' had 15, 17, and 24 full-time employees, respectively, while 'Step Child' employed seven, but frequently had no more than three or four people working full-time, given dual responsibilities and turnover.

4.2 Business strategy and marketing

'Step Child' was the only institution with no MBAs or employees with business backgrounds of the four. 'Step Child' was also the only office without graduate business interns working in tandem with scientists and legal experts to evaluate the commercial potential of disclosed inventions. 'Veteran', the most successful model, used their interns as a future employee pool to fill vacancies that arose. All offices except 'Step Child' had ongoing relationships with entrepreneurship programmes at their universities' business programmes.

4.3 Intellectual property protection

While 'Veteran' had many success stories over time and was well known to the research community, the most successful institution in gaining access to disclosures at the earliest points was 'Phoenix', which had a formal programme of reviewing all funded research projects and contacting researchers about the direction and timing of their research. Neither 'Transition' nor 'Step Child' had formal programmes to increase researcher awareness of the office and why early disclosure was important. The institutions varied widely on how early and how selectively they pursued patents on disclosures. 'Veteran's' policy is to patent on speculation, early and pre-emptively; however, they also have the largest budget for such activities. 'Transition' also prosecutes patents on speculation, although they have relatively few disclosures and so even with a limited budget, can afford to follow this path. 'Phoenix's' approach is to get to the invention at the research funding stage and make a decision at that point; however, they require a thorough test of marketability, requiring their researchers to test the technologies and an interdisciplinary team including industry experts to provide 'proof of concept'. 'Step Child' has a very limited budget for patents and tends to patent domestically and only for fairly broad patent applications.

4.4 Performance benchmarking

All four institutions reported using the AUTM data for external benchmarking. 'Veteran' has the most extensive list of performance measures, including not only number of licences and revenues produced from licensing (as do the other three), but also revenues received by their office, revenues received by the departments for additional research funding, and equity owned in start-ups using their inventions and discoveries. 'Phoenix' tends to follow the process from cradle to grave, tracking invention disclosures, patents filed, number of licences granted, ratio of legal fee reimbursements and executed service agreements. 'Transition' is in the process of setting up performance benchmarks, and 'Step Child' has few benchmarks other than external AUTM peer data, citing the variability across time periods and lack of comparability as reasons for not developing these standards.

4.5 Revenue generation focus

Three out of four sample institutions focus almost exclusively on licensing, as startups and spinouts require significant venture capital investment. Again, 'Veteran' takes the lead in the startup category. Because it is located in a geographically desirable and

commercially dense section of the country, it has readily available consumers for, and funders of, its intellectual property. Now that this institution has many venture successes to point to, it also has significant human and financial resources to draw from to create more ventures. Success breeds success. Obviously, these factors are not the same for many other institutions. 'Phoenix' has chosen to focus only on marketing their technologies to potential licensees. 'Transition' is also focused primarily on licensing, although they do not rule out startups. 'Step Child' wants to do it all; they hope to persuade local investors and governments to fund startups as part of an economic development effort, but as yet have not been able to garner funding and structural support for this direction.

4.6 Business stakeholder relationships

Both 'Phoenix' and 'Veteran' have well-developed relationships with the local and broader business community, as well as with venture capitalists and other potential funding groups. 'Veteran' has its own venture capital fund to invest in University start-ups. 'Transition' realises the importance of developing such relationships and is beginning to focus on establishing them, while 'Step Child' has no specific ties. While longevity is not necessary for such relationships, it seems to help. However, having a desirable location that presents more opportunities for interacting with the business community and the willingness to reach out beyond the local community (e.g., 'Veteran' and 'Phoenix') may be more important to achieving success on this dimension.

4.7 Institutional support

Of the four institutions, only 'Phoenix' mentioned that their President was involved in actively supporting technology transfer. It also offers regularly scheduled technology transfer seminars for researchers. 'Veteran', because of its extensive history, programmes and relationships with the broader internal and external communities may take their ongoing support for this function as a given. Both 'Transition' and 'Step Child' struggle with getting the attention of the university senior management and administrators, whether for human and financial resources, facilities or media coverage.

4.8 Project structure

A study by Bercoitz et al. (2001) of three different technology transfer organisations suggested that universities have differing degrees of centralisation. Because the organisations we studied were all centralised, we did not expect a variation on this dimension. However, we did discover the existence of two general forms for organising projects within a TTO, which one office had named 'marathon' and 'medley'. The term 'marathon' is used for projects in which a single point of contact is assigned to handle an invention from disclosure through revenue generation stages. The term 'medley' is used to describe projects in which an interdisciplinary team handles various stages from disclosure to revenue generation, either in tandem or serially. The most successful institution, 'Veteran', is the only institution to use a pure 'marathon' structure, while 'Phoenix' and 'Transition' use a modified 'medley' structure. 'Step Child' follows a pure 'medley'. However, the 'medley' models vary significantly. 'Phoenix' consciously uses a planned hybrid form, with a team handling the invention evaluation decision, then

handing the invention over to one case manager. 'Transition' begins with 'marathon', but that often morphs into 'medley' due to personality conflicts. 'Step Child' uses 'medley' by default, in that whoever is available to work on a project at a given time works on it. 'Phoenix' was the only office serving multiple campuses within the university system; 'Transition' and 'Veteran' had only a single campus and a single technology transfer office serving it. 'Step Child' operated within a multi-campus system with separate offices at each campus. In addition, 'Step Child' was the only office in which the marketing and licensing office was separated organisationally from the disclosure and patenting offices. Finally, 'Step Child' reported to two different vice presidents: operationally through the research arm of the university and financially through the administrative side.

Table 2 Summary of critical success factors achieved by four case-based models (see online version for colours)

Comparative dimensions	*'Transition'*	*'Phoenix'*	*'Veteran'*	*'Step Child'*
Age (years)	10	*	40	14
Size (full time employees)	15	17	24	7
Business strategy and marketing	✓	✓	✓	✗
Intellectual property protection	✓	✓	✓	✗
Performance benchmarking	✗	✓	✓	✗
Broad revenue generation	✗	✗	✓	✗
Business stakeholder relationships	✗	✓	✓	✗
Institutional support	✗	✓	✓	✗
Project management	✗	✓	✓	✗
Website quality	✗	✓	✓	✗

Note: *While this office has been in existence for several decades, within the past three to four years it has completely reinvented itself.

4.9 Internal and external website utility

In hindsight, we probably should have included this factor in our original list. According to Palmer (2002), websites are an important differentiator between TTOs which can enhance the establishment of 'virtual proximity' with potential collaborators if the websites are perceived as highly usable (e.g., rapid display rates, easy to navigate, content amount and variety, interactive, and responsive) (Palmer, 2002). Along this dimension, three of our four institutions did a reasonably good job with their internal website focus, including key forms and information for researchers. 'Veteran' provided not only the richest information, but also the simplest and most user-friendly to navigate. This may contribute to their not needing to do as much internal marketing to inventors. 'Phoenix' includes performance measurement on their site, along with their strategic plan. 'Step Child' was the weakest of the four in this area. In the external website domain, all

institutions except 'Step Child' included a comprehensive list of patents available to licensees. Again, 'Veteran' took the lead with a highly user-friendly and information rich site. Not only does it list, like 'Phoenix' and 'Transition', websites the patents available for licensing, but it also provides information on past success stories, links to all startup companies using the institution's technologies, and the process entrepreneurs, existing companies, and investors will need to go through to learn about and licence the university's technologies. The website is also used to attract new employees and student interns.

Table 2 summarises the performance of each of the four institutions on the critical success factors identified in both the literature, as well as those found in this study.

4.10 Other issues arising from the case studies

To conclude this section, we wanted to point out two factors that were identified in prior research and two additional factors that emerged from this research which were not directly addressed in our study. First was the issue of university prestige as a goal of technology transfer activities. Our sense was that while it might be possible to judge the degree of prestige a university had achieved from external sources, the interviews that we conducted were unlikely to elicit much variance on this dimension or provide evidence of a direct and non-spurious link between institutional technology transfer activities and prestige. Second, while our questionnaire did not elicit enough directly relevant information to formally analyse institutional alignment, several points made by respondents were of interest. These included the suggestion that faculty should be rewarded via promotion and tenure for technology transfer activities. Other recommendations received were for the technology transfer office to supply sufficient funding for patenting a larger percentage of inventions, as well as employ skilled negotiators and marketers to seek customers for those inventions. A final suggestion was to avoid inflexible and bureaucratic procedures which discourage faculty participation or movement between moving back and forth between industry and academia.

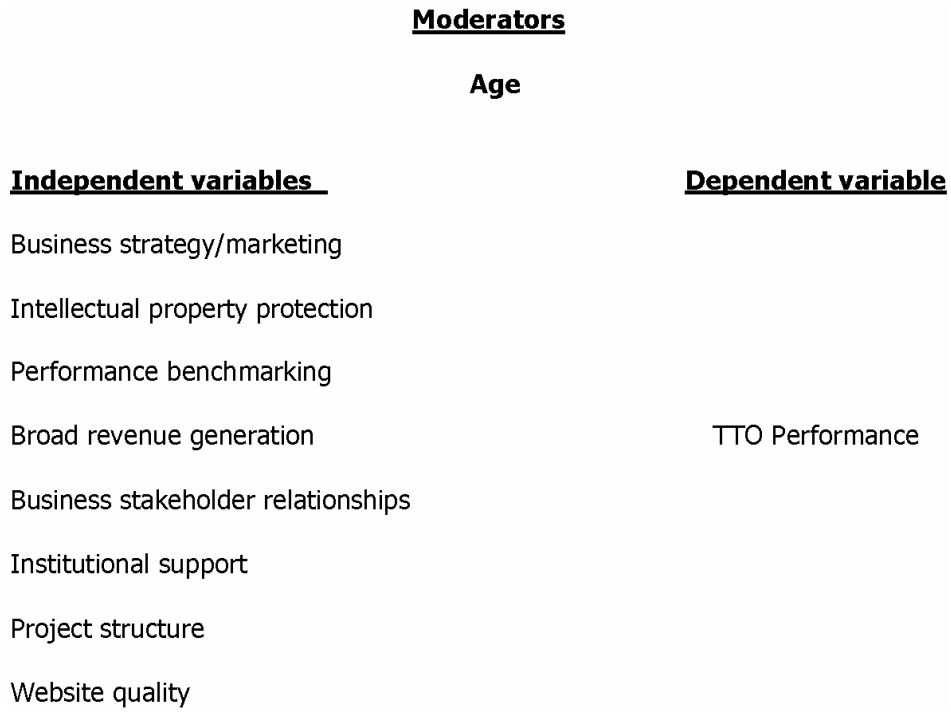
Turning to issues that emerged that were not addressed, the issue of economic development pressures arose during our interview process, and, while we did not delve directly into it, this is an interesting and important question for technology transfer offices and especially for those associated with state universities, which all of ours were. While one might think that a focus on local job creation would tend to be political, carry a short time horizon for achieving results, and favour licensing over startups, 'Veteran', the most successful institution, was the only one to measure jobs created and the number of companies using their inventions that remained in their city. This seems to be a paradox that bears more examination. A second emergent issue that was surprising to us was that while the age of the technology transfer office may be a factor that moderates several success dimensions, we would not expect it to be a significant direct success factor based on the dramatic and rapid success of 'Phoenix', which seems to be following in 'Veteran's' footsteps and achieving similar success. A final issue that emerged as a significant but not directly controllable factor is whether the office has hit a 'home run' in the past. By 'home run', we mean that one or two patents have generated millions of dollars for the respective institution. There are a limited number of US universities that currently qualify to be placed in this category (e.g., University of California, Stanford University, MIT, Columbia University), and even the elite derive a high concentration of intellectual property revenues from a small number of patents (e.g., University of

California TTO receives 76% of revenues from their top 25 inventions) (Meseri and Maital, 2001; University of California, 2008). None were in our sample because we consider them outliers. Clearly, while such 'home runs' create incredible visibility and resources, as one tech transfer office manager quipped, "If we could pick the 'home runs' with any degree of success, I could retire rich."

5 Model and propositions

From the dimensions contained in Table 2, two distinct clusters or models emerged representing successful and unsuccessful technology transfer processes. Figure 6 summarises this testable model of technology transfer office success.

Figure 6 A model of TTO performance



Theoretical propositions arising from the models are as follows (note that all propositions below make a ceteris paribus assumption; that is, that all other factors other than the one under investigation are considered to be equivalent):

P1 *TTOs that take a strategic approach to their operations and actively engage in both market research and marketing will be more successful than TTOs that do not.*

P2 *TTOs that engage in early stage, broad and preemptive intellectual property protection will be more successful than TTOs that do not.*

P3 *TTOs that proactively engage in both internal and external performance benchmarking will be more successful than TTOs that do not.*

P4 *TTOs that focus on maximising value via both licensing and spinoffs will be more successful than TTOs that do not. However, this focus is contingent on there being sufficient resources to do both activities.*

P5 *TTOs that actively foster external stakeholder relationships will be more successful than TTOs that do not. However, constraints to forming such relationships may be TTO longevity and location of the institution.*

P6 *TTOs that have strong institutional support will be more successful than TTOs that do not.*

P7 *TTOs that employ a pure "Marathon" or a planned "Hybrid" model for managing projects will be more successful than TTOs that do not.*

P8 *TTOs that have easy-to-use, comprehensive, and informative websites that appeal to both internal and external stakeholders will be more successful than those that do not.*

Our conclusion is that university technology transfer offices that embrace the above propositions are more likely to be successful than those that do not. These results are consistent with those of Siegel et al. (2007), who suggest that organisational practices are a significant predictor of relative TTO performance, contrary to conventional economic models which predicted that environmental and institutional variables were the two dominant factors.

6 Conclusions and future research directions

Our study has resulted in two models of university technology transfer office performance, based on semi-structured interview data from four peer case studies (along with data from AUTM and 48 additional University Technology Transfer Office websites). However, we believe that it has made contributions to advancing research in the under-researched and important area of technology transfer success in at least three other ways.

First, our research integrates a range of key university technology transfer office success factors outlined in a variety of different studies. However, one factor not explicitly explored in, and beyond the scope of, this study is the role that organisational culture plays in the development of university technology transfer office processes and, ultimately, in their success. While this is a relatively new and underexplored research topic, several authors suggest that of all TTO stakeholders, the internal academic community is most important, at least in the beginning. Campbell (2007), along with Plewa et al. (2006), emphasise that institutions hoping to be successful at technology commercialisation must signal to researchers that they support and encourage their active engagement in the technology transfer process. Our suggestion is to expand the institutional alignment factor to incorporate multiple dimensions of institutional culture.

Second, our study triangulates TTO success factors put forth in the literature with data from institutions that vary in terms of their perceived technology transfer office performance. A unique contribution from a data perspective is the combination of information obtained from semi-structured, confidential, in-depth interviews with data publicly available from a larger set of TTO websites. The inclusion of the website qualify

variable, which we added as a result of noticing differences in preparing for the in-depth, semi-structured interviews, is an additional contribution to the comprehensive model of TTO success. However, as one of our reviewers noted, our determination of the quality of information on those websites was somewhat subjective; the order in which the office appears using common search engines and common search terms might be a more objective way to assess website value to external stakeholders. To test this idea, we entered the search term 'university technology transfer office' into Google and found that 'Phoenix' turned up on the first page followed by 'Transition', while Veteran did not appear until the third page and Step Child did not appear at all. This ranking seemed consistent with the goals of the offices, with 'Phoenix' and 'Transition' seeking to improve operations, 'Veteran' being more established and thus perhaps not needing as much PR and marketing, and 'Step Child' lagging in this dimension as in others. To assess internal stakeholders' perception of website value, researchers could catalogue and compare the services listed by the TTO.

Third, our research provides a set of propositions which can be tested by surveying a much broader sample of institutions in order to provide generalisability. While operationalising and testing these propositions is left for future research, we would suggest several approaches to this task. Over the last twenty years, a range of academic papers have been published (some cited in this study) which have empirically investigated one or more of the TTO success factors addressed above. As such, they often can provide a roadmap for measuring and testing specific factors for inclusion in more comprehensive models such as the one we present. Also, as university TTOs provide increasing levels of detail on their websites, it may be possible to collect and code differences in factors such as marketing emphasis, performance benchmarking, the degree to which external stakeholder relationships are fostered, and the level of institutional support. The University of Colorado website provides an example of open and transparent TTO information, but others are increasingly following suit. Internal process information will remain difficult to obtain through means other than surveys and interviews. To operationalise the Marathon/Medley/Hybrid project management techniques, for example, defining the terms and then offering TTO managers examples of each in order for them to choose the model that best fits their processes is likely to result in valid and reliable data. Obtaining resumes of key TTO employees from sources such as business networking sites such as Linked In might provide information as to offices' relative capabilities of engaging in market research and marketing activities. In terms of analytical models for testing the set of factors, we would suggest using path analytic or structural equations models in order to capture not only temporal dimensions of the process but also relationships amongst factors.

As a final caveat, at least three emerging factors were not addressed in our study for different reasons. First, while there is a growing body of literature addressing regional innovation, which may be a factor in university technology transfer success (Doloreux and Parto, 2004), because our study was confined to firms within a single region that does not yet have an ecosystem as rich as those surrounding Boston, Silicon Valley, the Research Triangle in North Carolina, or Austin, there was no regional variation to investigate. Second, recent research sponsored by the Ewing Marion Kauffman Foundation (Gulbranson and Audretsch, 2008), suggests that for universities which excel at research and have access to investment capital networks, such as MIT and UC-San Diego, proof of concept centres can contribute to technology commercialisation success. The study identifies a handful of universities that are likely to be able to provide the

funding, advisory services, and education needed to accelerate academic innovation. Because these necessary resources were less available in the region that we studied and because the approach is still so new and relatively small in scope, we did not include this variable in our model. However, for richer and more developed university research ecosystems, this is an important next step. Finally, although our study makes no distinction among broad institutional missions of the technology transfer offices surveyed (e.g., public good, revenues, productivity), the in-depth nature of our research has convinced us that the same success factors will affect most of these goals in the same way. However, that assumption is open to empirical investigation in future studies.

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Appendix 1

Case study survey questions

1 In what stage in their research do the researcher/ inventor contact your office about their findings? At what stage would your office, ideally, want to be contacted?

2 For a given technology, who, if anyone, is responsible for seeing the entire process through?

3 Are people aware of your office and its function? If so, what did your institution do to raise awareness?

4 How does your office measure its success? What benchmarks are used?

5 In your process, are technologies tested with end users before patenting? When in the process?

6 Does your office patent on speculation (MIT) or once the licensing agreement is in place (California)?

7 Is your office able to follow-up and enforce licence agreements? Do you have the people to do it? If you are able, who does it?

8 What programmes, partnerships, relationships, and resources does your institution have in place to attract investment?

9 If you had unlimited resources to set up your office how you wished what would it look like? How close is this to your reality? What institution would you or do you model after?

Appendix 2

University technology transfer websites visited

Technology Research and Development Center of Alaska	http://www.trendalaska.org
Auburn University – Industrial Programs and Technology Transfer	http://www.auburn.edu/research/vpr/ipttadm
Boston University Office of Technology Transfer	http://www.bu.edu/otd/
Carnegie Mellon Technology Transfer Office	http://www.carnegiemellonctt.com/
Columbia University – Columbia Innovation Enterprise (CIE)	http://www.stv.columbia.edu/
Cornell University – Center for Technology, Enterprise and Commercialization	http://www.cctec.cornell.edu
Dartmouth College – Technologies Available for License	http://www.dartmouth.edu/admin/tto
Georgia Tech Applied Research Corporation	http://www.gtarc.gatech.edu
Iowa State University – Office of Intellectual Property and Technology Transfer	http://www.techtransfer.iastate.edu/
Johns Hopkins University – Applied Physics Laboratory, Office of Technology Transfer	http://www.jhuapl.edu/ott
Johns Hopkins University – School of Medicine, Office of Technology Licensing	http://www.jhtt.jhu.edu/
Mississippi Enterprise for Technology University	http://www.mset.org/index1.html
Northern Illinois University Technology Commercialization Office (TCO)	http://www.grad.niu.edu/tco
Office of Industrial Liaison – OIL at the Albert Einstein College of Medicine	http://www.aecom.yu.edu/oil
Ohio University - Technology Transfer Office (TTO)	http://www.ictto.ohiou.edu/technology.php
The Ohio State University – Center for Materials Research	http://www.physics.ohio-state.edu/~cmr
Oklahoma State University Technologies Available for Licensing	http://www.vpr.okstate.edu/intprop/LICENSING.HTM
Oregon State University – Technology Transfer	http://oregonstate.edu/research/techTransfer.html
Penn State Research and Tech Transfer Organization (RTTO)	http://infoserv.rttonet.psu.edu/index.htm

University technology transfer websites visited (continued)

Princeton Technology Licensing and Intellectual Property	http://www.princeton.edu/patents
Rice University – Office of Technology Transfer	http://ott.rice.edu
Simon Fraser University (SFU) University/Industry Liaison Office (UILO) – Burnaby, British Columbia	http://www.sfu.ca/uilo
Stanford University – Office of Technology Licensing (OTL)	http://otl.stanford.edu
SUNY at Stony Brook – Technology Transfer	http://sumweb.syr.edu/summon/osp/public/web
Texas A&M University – Technology Licensing Office	http://www.otc.utexas.edu/
University of California, Davis – Technology Transfer Center	http://ovcr.ucdavis.edu/ttc
University of California, Los Angeles	http://www.research.ucla.edu/oipa/
University of California Irvine – Office of Technology Alliances	http://www.rgs.uci.edu/rig/ota/otaindex.htm
University of California's Office of Technology Transfer	http://www.ucop.edu/ott
University of Chicago – ARCH Development Corporation	http://www-arch.uchicago.edu
University of Colorado – Technology Transfer	http://www.cu.edu/techtransfer/
University of Florida – Office of Research and Graduate Studies	http://www.otl.ufl.edu
University of Hawaii – Office of Technology Transfer and Economic Development	http://www.mic.hawaii.edu
University of Houston – System	http://www.research.uh.edu/otm/techmanage.html
University of Maryland Baltimore County – Office of Technology Development	http://www.umbc.edu/otd
University of Maryland at College Park Graduate Studies and Research – Office of Technology Liaison	http://www.otl.umd.edu
University of Miami – Office of Technology Transfer	http://www.miami.edu/techtransfer/
University of Michigan – Technology Management Office	http://www.techtransfer.umich.edu
University of Pennsylvania – Center for Technology Transfer	http://www.upenn.edu/ctt
University of Texas at Dallas	http://www.utdallas.edu/research

University technology transfer websites visited (continued)

University of Texas M.D. Anderson Cancer Center	http://www.mdanderson.org/~otd
University of Texas – Masters Degree	http://www.ic2.org/msdegree
University of Utah	http://www.utah.edu
University of Utah – Technology Transfer Office	http://www.tto.utah.edu
University of Virginia Patent Foundation	http://www.uvapf.org
University of Wisconsin-Madison Corporate Relations	http://www.corprelations.wisc.edu/
Vanderbilt University – Office of Technology Transfer	http://www.vanderbilt.edu/technology_transfer
Virginia Tech – Business Resources Guide	http://www.vtconnect.vt.edu
Virginia Tech Intellectual Properties, Inc.	http://www.vtip.org
Wisconsin Alumni Research Foundation	http://www.warf.ws/
Wyoming Technology Transfer Center	http://wwweng.uwyo.edu/wyt2