Available online at www.sciencedirect.com

SCIENCE DIRECT®

Journal of Business Venturing 20 (2005) 241–263

JOURNAL of BUSINESS VENTURING

Entrepreneurship and university-based technology transfer

Gideon D. Markman[a,*], Phillip H. Phan[b,1], David B. Balkin[c,2], Peter T. Gianiodis[a,3]

[a]*Terry College of Business, University of Georgia, Athens, GA 30602-6256, USA*
[b]*Lally School of Management and Technology, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180-3590, USA*
[c]*Leads School of Business, University of Colorado at Boulder, Boulder, CO 80309, USA*

Abstract

The success of business incubators and technology parks in university settings is often determined by how well technology is transferred from the labs to their startup firms. University technology transfer offices (UTTOs) function as "technology intermediaries" in fulfilling this role. Yet, entrepreneurship theory and research on the role of the UTTO in business incubation and new venture formation is sparse. To move the research along, we use grounded theory to build a framework to address two questions: (a) Which UTTOs' structures and licensing strategies are most conducive to new venture formation; and (b) how are the various UTTOs' structures and licensing strategies correlated with each other. Our findings reveal a complex set of relationships between UTTO structure and strategies, new venture formation, and business incubation.

Based on interviews with 128 UTTO directors, we show that whereas for-profit UTTO structures are positively related to new venture formation, traditional university and nonprofit UTTO structures are more likely to correlate with the presence of university-based business incubators. Licensing-for-equity strategy is positively related to new venture formation while sponsored research licensing strategy is negatively related. Interestingly, the licensing-for-cash strategy, the most prevalent transfer strategy, is least correlated to new venture formation. A content analysis of UTTO mission statements also revealed an overemphasis on royalty income and an underemphasis on entrepreneurship. The

* Corresponding author. Tel.: +1-706-542-3751; fax: +1-706-542-3743.
E-mail addresses: gmarkman@terry.uga.edu (G.D. Markman), pphan@rpi.edu (P.H. Phan), david.balkin@colorado.edu (D.B. Balkin), gianiodi@arches.uga.edu (P.T. Gianiodis).
[1] Tel.: +1-518-276-2319; fax: +1-518-276-8661.
[2] Tel.: +1-303-492-5780; fax: +1-303-492-5962.
[3] Tel.: +1-706-542-4666; fax: +1-706-542-3743.

0883-9026/$ – see front matter
doi:10.1016/j.jbusvent.2003.12.003

paper concludes with a discussion that outlines some of the implications and limitations of our model.

Keywords: Entrepreneurship; Technology transfer; Business incubators; UTTO

1. Executive summary

With considerable profits at stake, many research universities are seeking to more effectively manage how their ideas and discoveries are deployed and sold. Perhaps this is the reason why with the exception of such institutions as Harvard, Boston University, Stanford University, and the like, who were already part of new venture "nurseries" or ecologies of emerging organizations, 62% of the universities and their communities in this study are establishing business incubators and building research parks as ways to encourage technology-based new ventures and economic development.

Within this ecology of knowledge creation and business formation, university technology transfer offices (UTTOs) are increasingly functioning as "technology intermediaries" that transmit technological innovations from the lab bench to industry. As we noted in the abstract, the extant entrepreneurship theory and research on the role of UTTO in new business creation and business incubation is sparse and so to advance our understanding of this issue, we use grounded theory to build a framework around the following questions: (a) Which UTTOs' structures and licensing strategies are most conducive of new venture formation? and (b) How are UTTOs' structures and licensing strategies correlated?

Interviews with 128 UTTO directors and a content analysis of university policies revealed that a UTTO is organized into three archetypes: (a) traditional university structure, (b) nonprofit 501(C)1 research foundation, and (c) for-profit private venture extension. These structures grant increasing degrees of autonomy to the UTTO managers in their pursuit of technology commercialization opportunities. A patent-protected technology is commercialized through one of three main licensing strategies: (a) licensing in exchange for sponsored research, (b) licensing for equity in a company, and (c) licensing for cash. While the strategic choice to commercialize proprietary technology depends on many factors, interviewees report that their decisions are strongly influenced by the stage of the technology, which they classify into four overlapping categories including early-stage inventions, proof of concept, reduction to practice, and prototyping.

Results based on qualitative and quantitative data show correlational links between UTTO structures, transfer strategies, the creation of new ventures, and business incubation. For instance, for-profit UTTO structures are positively related to the transfer of new technology via new venture formation. While traditional and nonprofit UTTO structures are uncorrelated with venture creation, they do correlate with the presence of a university business incubator. We found that both licensing in exchange for equity and for sponsored research are related to new venture formation, although the former is negatively so while the latter is positively so. The strategy of licensing for sponsored research is negatively

correlated with the existence of a university-based business incubator, which is in part a reflection of the stage of technological maturity. Another important finding is that the licensing-for-cash strategy (the most prevailing transfer strategy in our study) is least related to new venture creation.

The relationships we found between UTTO structures and licensing strategies are also interesting. For example, both traditional and nonprofit structures are related to licensing strategies that favor sponsored research, but the former is positively related while the latter is negatively related. On the other hand, traditional and for-profit structures are positively related to licensing strategies that favor the creation of new ventures. For-profit structures, probably due to UTTOs' competencies in business development, seemed to provide the strongest support for new venture creation.

Taken as a whole, this study advances our understanding in the following ways. With the exception of insightful but narrow case studies there is currently no broad framework for understanding the relationships between UTTO organization, licensing strategies, and the process of technology transfer-inspired new startups. We have done so using a near-census data collection technique that captures the entire phenomenon to develop a model that *simultaneously* explains UTTO strategies, structures, and outcomes.

From a public policy standpoint, taxpayer support for university basic research is traditionally justified by a return-to-society on investment argument. Therefore, universities are pressured to show tangible returns for the research grants they receive. We found that in response universities are increasingly viewing themselves as catalysts of new venture formation and regional development. They view the process of technology transfer as a channel through which this role can be fulfilled. In fact, we found that UTTOs play a key role in economic development by adopting various configurations and enacting different transfer strategies that appear to correlate with varying levels of new venture formation. However, there is an inherent conflict between realizing immediate income through licensing for cash and ensuring long-term cash flows through licensing for equity. Indeed, research shows that in the long run taking equity in startups produces a greater return than the average cash license arrangement. Still, we found that although licensing for equity is more likely to drive new venture emergence, the UTTO motivation to maximize cash flows and minimize financial and legal risks often lead to a strategic choice that undermines new venture creation.

The substantial growth in universities' patenting and licenses activity has prompted policymakers to debate the possible "unintended" effects of the Bayh–Dole Act, such as the apparent shift toward applied research in place of basic research. Our findings that universities employ different UTTO configurations with varying levels of autonomy could raise concerns that expectations of financial returns would, over time, increase the allocation of capital to applied research and reduce the capital to basic research. Although we report that licensing for cash is the predominant licensing strategy, we note that none of the structures are significantly related to the cash strategy. In fact, the for-profit structure was actually negatively related to this licensing strategy. Thus, the "problem" of a shift from basic to applied research may be overstated, at least as it applies to a university's licensing strategy.

2. Entrepreneurship and university-based technology transfer

At its core, entrepreneurship is about the "why, when, and how opportunities for the creation of goods and services come into existence," (Shane and Venkatramanan, 2000, p. 218) and scientific discoveries are a key precursor to this process (Schumpeter, 1950). Nowhere is scientific discovery more salient to new venture creation than in research-oriented institutions of higher learning, the modern seedbeds for scientific breakthroughs and technological innovation. In fact, research on knowledge spillover and organizational learning suggests that continuous interactions among creators, appropriators, and consumers of technology accelerate the richness and reach of knowledge and discoveries (Agrawal and Henderson, 2002; Cockburn and Henderson, 1998; Zucker and Brewer, 1998; Zucker et al., 1998). Thus, the need to organize the process of accelerating technology spillover and innovation in universities is often a principal driver behind the establishment of technology transfer offices, business incubators, and science parks (Link et al., in press; Siegel et al., in press).

The 1980 Bayh–Dole Act, the 1980 Stevenson–Wydler Act, and the 1985 Federal Technology Transfer Act lead to a fundamental change in the way scientific discoveries at universities and Federal laboratories were commercially exploited. Since then, the number of U.S. universities that engage in technology transfer and licensing have increased eightfold, to more than 200, and the volume of university patents has increased fourfold (Mowery and Shane, 2002). The importance of technology commercialization and its impact on new venture creation through business incubation motivates this research. Our objective is to induce a theoretical model that explains the relationship between technology transfer strategies, organization structure, and new firm creation in U.S. research universities.

From 1991 to 1997, university license revenues increased over 315%, from $220 million to $698 million (Association of University Technology Managers [AUTM], 2000, 2002). The number of startup and mature firms that utilize technologies developed by university faculty, staff, and students skyrocketed with the result that venture capitalists are increasingly interested in university-founded technology firms (cf., Small Business Association, 2002). Coupled with Internet-related startups of the late 1990s and the resulting explosion of venture capital financing for technology-based new businesses, universities, sometimes in partnership with regional economic development agencies, intensified their focus on turning their proprietary technology into economic opportunities (Siegel et al., 2003).

Hence, where in the past universities have passively licensed their technologies today many research universities actively search for ways to channel proprietary technology to maximize rents and to spawn new companies (Thursby et al., 2001). Through their office of technology transfer, many U.S. research universities are becoming an integral part of a larger business community that links scientists to a value chain of business startups, incubators, science parks, and industry. For example, at Rensselaer Polytechnic Institute (RPI), a private science and engineering university in Upstate New York, the transfer of university technology into student- and faculty-founded businesses represents a conscious effort to create wealth and increase economic development from scientific discoveries. Budding ventures often relocate from the science labs to the RPI Incubator, which houses more than 35 new ventures

at any one time, all of which are student or faculty founded firms. In turn, successful ventures can eventually migrate to the RPI Technology Park. This network of value creation entails many constituencies—inventors, scientists, universities, incubators, and technology parks—and where UTTOs often play a key role. Thus, UTTOs are fundamental to the successful transfer of technology to industry (Link et al., in press; Siegel et al., in press).

In spite of its important role, questions of what UTTO organizational configurations and licensing strategies are most beneficial to new business formation have yet to be fully answered. To this end, we employed a grounded theory approach to build a conceptual model that links the work of UTTOs and the creation of university-spawned businesses. Our primary objective was to address the following two questions: (a) Which UTTOs' structures and licensing strategies are most conducive to new venture formation? and (b) How are UTTOs' structures and licensing strategies related to each other? We next describe the methodology of our research, with special attention paid to the process of data collection for theory building.

3. Theory building methodology

Our paper employs grounded theory, which is an applied methodology of analysis linked with qualitative data to induce a theory (Creswell, 2002; Glaser and Strauss, 1999; Strauss and Corbin, 1998). Grounded theory is prescribed when constructs or phenomena are not well understood (here, the nature of UTTOs as intermediaries of knowledge and opportunities); there is no established theory that explains the links between the phenomena of interest (here, the relationships between UTTO' structure, strategy, and new venture formation); and/or the relationships between constructs that are not well understood in particular contexts (here, at what point transferred technology creates new business opportunities). To answer our questions, we interviewed 128 UTTO directors, who have first-hand experience in the phenomenon being studied and are thus most qualified to provide valuable insights and interpretations of their domain. More importantly, since many UTTOs are recently formed and are still evolving, one cannot rely on an empirical deductive (i.e., hypothesis testing) approach to theory building because we have simply no confidence that existing theoretical frameworks have accounted for the phenomenon in its entirety. In short, theory verification at the emergent stage of a phenomenon is not recommended and so we employ a positivist inductive approach to theory building (Eisenhardt, 1989).

Our primary data collection device is the long interview. We ensured that we always spoke to the Director of the UTTO since this person would be most conversant with university policies and commercialization strategies. We commenced with open-ended interviews with seven UTTO directors, who helped us understand and inventory the organizational configurations of UTTOs, their transfer strategies, and their missions (cf., Holstein and Gubrium, 1995). Of the initial seven interviewees, three worked for small, medium, and large private universities, while the other four worked for medium and large public universities. To improve response rate and reduce social desirability, we assured the participant's anonymity. The interviews averaged 90 minutes; four were conducted over the telephone while three were conducted in person. Once we understood better the nature of a UTTO's work, we

employed structured interviews with an additional 121 UTTO directors using narrower and more focused sets of questions, with each set becoming more focused as we reached theoretical saturation (Eisenhardt, 1989). At this point, an inventory of constructs, the typology of dimensions of the constructs, and the relationships between the constructs became clarified. Specifically, we identified a set of three UTTO structures, three main commercialization strategies, and four technology stages. From the interviews, we then explored the UTTO structures and technology transfer strategies that would most likely lead to new venture creation.

While some might question the external validity of this design, we feel that this is not a serious issue in a positivist approach to grounded theory. First, in building the theoretical model, we deliberately constrained its context to UTTOs in research universities in the United States. Issues of external validity are partially addressed by concentrating on the larger problem of internal validity and reliability and by cross-referencing the qualitative and quantitative data with other sources (e.g., UTTO websites, official university reports, data from various AUTM publications, and internal documents provided by UTTO respondents). We also validated interviewees' accounts with published university policies and internal documents, highlighting those areas for further clarification where our findings may contradict or elaborate on past research. This triangulation approach increased the confidence that the quantitative and qualitative data were accurate and that our interpretations of the data were true to the intentions of the interviewees.

Second, and in contrast to past research on this topic, we used a near-census sample of UTTOs. In total, we interviewed 128 UTTO directors representing over 60% of federal and industry research grants and over 70% of executed licenses, invention disclosures, and new patent applications. Our sample was drawn directly from the universe of 139 U.S. universities in the AUTM for 1999, the most recent list available. Our response rate represented over 92% of the AUTM population. This near-census sample ensured that our model is theoretically saturated and that we have observed the phenomenon in its entirety (Flint et al., 2002).

4. The theoretical model

UTTO personnel administer the commercialization process of a university's intellectual property (IP), defined as patents, copyrights, trademarks, various know-hows, and related assets. At the most general level, UTTO personnel are responsible to (a) evaluate and valuate disclosures of new discoveries; (b) seek legal protection for the technology, primarily through patenting; (c) sell licensing agreements to industry; and (d) collect royalty, oversee, and enforce contractual agreements with licensees. At the same time, because UTTOs are part of a value creation chain, their structures and licensing strategies might have a strong influence on technology transfer outcomes such as new venture creation. Hence, in the following sections we provide aggregated descriptions of UTTOs' structures and licensing strategies as they emerged from the interviews and other data sources provided by the respondents. The data were cross-validated with formal university documents.

4.1. Structures: how universities house their UTTOs

Our interviews revealed that UTTOs are organized into three archetypes, which vary by the degree of autonomy granted at the institutional level to pursue technology commercialization opportunities. These structures are (a) traditional university structure, (b) nonprofit 501(C)1 research foundation, and (c) for-profit private venture extension. To establish reliability and convergent validity, we also researched each institution's website to corroborate these organizational structures. As we describe each of these organizational structures, it is important to keep in mind that of the 128 UTTOs studied, over half (52%) conformed to the traditional university structure, 41% were nonprofit research foundation, and 7% operated as for-profit private venture extensions. In the interest of parsimony, Table 1 provides additional descriptions and examples of each configuration.

4.1.1. Traditional university structure

A traditional UTTO is organized as an integral department within a university's administrative structure, usually reporting to the Office of the Provost or Vice President for Research. Such UTTOs are tightly supervised by an assistant or vice president of the university and is generally funded by the research office. Under this structure, which comprised 52% or 67 UTTOs in our sample, personnel are normally untenured university staff with the primary role of pursuing conventional licensing opportunities for royalty income. The direct, and often strong, oversight by a university administration limits the autonomy of UTTO management in matters of decision making, licensing strategies, and incentive systems. As one UTTO director from a public Northwestern school explained:

> Our goal was to have established an incubator by the end of last year to help facilitate entrepreneurial ventures, but we are still [9 months later] waiting for approval from university administration.

As this example illustrates, in addition to seeking patent protection for a discovery or launch a market study to determine the commercial potential of certain technologies, UTTO directors may need to seek formal university administration approval in building the necessary infrastructure to help facilitate their missions, in this example, entrepreneurial activities.

4.1.2. Nonprofit research foundation [501(C)1]

These UTTOs function as independent nonprofit units or part of separately constituted research foundations outside the university's administrative structure. Such research foundations, comprising 41% of 52 UTTOs in our sample, have their own Board of Directors, which is frequently chaired by the university president. Private universities and many large multisystem state universities create nonprofit research foundations to grant greater autonomy to faculty to conduct research and license new technology. In addition, many universities use this structure as it provides stronger legal protection against lawsuits stemming from licensing disputes, IP infringements, and even future product or service liabilities stemming from the university's licensed technology. UTTOs under this structure enjoy a separate budget from

Table 1
UTTO structures

UTTO structures	Description	Key features	Advantages	(Count/%) Examples
Traditional university structure	UTTO is part of the Office of the Provost for Research, a department within the university structure. It is run primarily by an assistant/vice president of the university and generally is funded by the research office.	UTTO officers are university employees In general, UTTO does more traditional licensing for cash/ revenue	UTTO is very simple to manage More direct control to university administration	(67/52%) Ex.: Johns Hopkins, Dartmouth
Nonprofit research foundation (501(C) 3)	UTTO is a separate entity or part of a separate "research" entity outside of the university structure. Research foundation is set by university/ state government (for large state universities) specifically to grant greater autonomy to conduct research.	Nonprofit corporation Board of Directors independent of university Separate budget from university In some states, allows university to hold equity President of university is generally chairman of research foundation	Limits liability General autonomy from university Ex.: Provides greater flexibility for employee pay, incentives, etc. (i.e., outside of university grade system) Ex.: Separate budget (i.e., no government entity can "seize" allocated dollars from the foundation to fill budget holes) Allows entity to invest revenues without constraint	(52/41%) Ex.: Land grant universities (University of Minnesota, University of Michigan, etc.); private universities (Cornell, Brown)
For-profit private venture extension	UTTO is either part of university structure or a research foundation, with a private venture extension. The private venture extension generally is focused on economic development and creating startup companies.	Private venture has independent CEO & Board Employees have startup/VC experience Aggressively create startups	Limited liability Greater flexibility/ freedom to "incent" employees Greater flexibility to raise outside capital	(9/7%) Ex.: Baylor College of Medicine, Boston University, University of Virginia

their affiliated universities, greater autonomy in choosing licensing strategies, and the ability to hold equity in startup companies created to exploit their licensed technologies. As one UTTO director from a public Midwestern University explained:

> . . . in addition to giving us better legal protection, this [research foundation] structure offers us greater freedom on hiring and hopefully, one day soon, incenting our officers . . .

This example demonstrates that nonprofit research foundations [501(C)1] enjoy more flexibility than the traditionally structured UTTO in terms of granting compensation and incentives to personnel with pay levels that can sometime exceed the university grade system.

4.1.3. For-profit private extension

Only 7% or nine UTTOs in our sample were created as separate private for-profit private venture extensions. Five of these UTTOs were physically housed in a research foundation described above, while four were an integral part of the traditional university campus. The for-profit private extension is focused on economic development and creating startup companies. Private extensions also have an independent CEO and a Board, with personnel who have substantial experience in such areas as IP law, managing companies, and venture capitalism. Our informants told us that private venture extensions were most aggressive at creating startups and raising capital—a fact that was corroborated by our own Web-based searches and analyses. For-profit UTTOs enjoy the greatest autonomy in terms of licensing strategies and compensation systems. As one UTTO director from a private Northeastern university explained:

> . . . our scientists are aware of the existing [entrepreneurial] network. Having the freedom to invest capital in these firms, as well as counsel them [on legal issues], provides us with a great opportunity to get in on the ground floor . . .

As with a nonprofit research foundation [501(C)1] the benefit to universities is even greater legal insulation against lawsuits. More importantly, such private extensions are freer to raise capital from government or state economic development programs, conduct negotiations with potential licensees and research partners, and act entrepreneurially to fund startup companies.

Although participants from each of the three UTTO structures expressed some interest in new business formation, most of our interviewees suggest that the third archetype would be most conducive to new business formation. This takes us to the first proposition in our model:

Proposition 1: *Of the three UTTO archetypes, the for-profit private venture extension is best positioned to accelerate new business formation.*

4.2. Licensing strategies

Our interviewees suggested that once a technology is patent protected, their office will try to commercialize the discovery through one of three licensing strategies: (a) licensing in exchange for sponsored research; (b) licensing for equity; and (c) licensing for cash.

However, since licensing strategies are driven, at least in part, by the technology in question, we begin this section with a short description of how UTTOs characterize the technologies they try to license. Table 2 provides more specific descriptions, culled from the interviews, of each technology stage.

UTTOs classify their technologies into four overlapping types: early-stage inventions, proof of concept, reduced to practice, and prototyping. UTTO directors conceptualized these overlapping categories along two continuums of uncertainty: ambiguity regarding whether a particular technology has market application and ambiguity regarding the robustness of the legal protection over the IP. As one might expect, early-stage inventions refer to discoveries based on basic research with highly uncertain market potential and in many cases unclear IP or prepatent protection status. On the other hand, prototyping refers to a technology with a relatively clearer market application and more robust legal protection (e.g., stronger patents). At the outset, it should be clear that licensing strategies are determined by many factors such as university mission, the budget for such activities, and so forth; so to determine each UTTO's primary licensing strategy we asked interviewees to describe the frequency distribution of their chosen licensing strategies. To be more precise, the question we asked stated, "UTTOs enact different commercialization strategies, including R&D capital; equity; and royalty cash. What is the average distribution of licensing strategies (out of 100%) across these three possibilities at your institution?" For example, the distribution of licensing strategies at a Northwestern U.S. university was 40% for sponsored research, 10% equity, and 50% for cash, whereas the licensing strategy of a prominent Southwestern U.S. university was entirely 100% for cash (0% for sponsored research and 0% for equity). As we describe each of the licensing strategies below, it is important to keep in mind that of the

Table 2
Technology stages

Technology stage	Description
Early stage	An early-stage technology may be an idea that might work should the idea be reduced to practice. This technology could also be a crude extract of some plant or cell that seems to have an in vitro effect. Neither the exact compound in the extract is known, nor has the exact mechanism of the effect been identified.
Proof of concept	An idea or new technology has been developed to the point that it shows signs of having the proposed effect. Similarly, a few target compounds in a crude extract may have been identified, but the mechanism by which they act may not have been discovered yet.
Reduction to practice	At this stage, an experiment on the idea has been replicated several times and the intended results have been reliably and repeatedly reproduced. The mechanism of the compound or compounds may have also been identified and, again, reliable results will have been produced.
Prototyping, formulation, compound	The new technology can now be constructed as a reliable method of producing a given result and/or if it can be predictably manipulated to produce desired results. For instance, a compound from a crude extract would have been either scaled up to industrial scale; based on its identified action, the compound could be used to screen for inhibitors or be used as a diagnostic tool. At this stage, new technologies might be applied in new and different settings.

128 UTTOs we studied, 11% sought primarily sponsored research, 17% sought primarily equity licensing, and 72% sought primarily cash royalty as their predominant licensing objectives.

4.2.1. Licensing for sponsored research

Interviewees suggested that this strategy is usually paired with early-stage technologies. Our data show that approximately 11% of the UTTOs we studied used this as their predominant licensing strategy. The interviews revealed several reasons why licensing technology in *exchange for sponsored research* is the least preferred strategy. First, although UTTOs and corporations appreciate the benefits of working together to develop new technologies, both parties are wary of subsequent disputes over research direction and ownership of the future IP. Second, because at this stage the technology is underdeveloped and requires additional R&D capital, firms are reluctant to lock themselves into licensing agreements or incur patenting fees, which can reach $250,000 in the case of an international patent (this cost involves obtaining separate patent protection in foreign countries), without being sure of whether the technology would work, fit their market needs, and provide exclusivity against competing patents. The third and most important reason is best illustrated by legal mêlées between universities, corporations, and inventors.[4] Such uncertainties and legal challenges have left many UTTOs hesitant about and reluctant to enter into licensing in exchange for sponsored research. As one UTTO director from a public Southwestern university explained:

> . . . we are well aware of the pending litigation [in California]. The last thing we want to happen is to turn a sponsored research agreement into future litigation . . .

While receiving tax-free industry support to fund ongoing research projects enables universities to reallocate their own funds among fewer departments and schools, the legal hazards seem to frequently outweigh the benefits at this stage. Similarly, many universities instruct their UTTOs to focus primarily on developing their royalty stream. As one UTTO director from a private Northeastern engineering school explained,

> Despite the importance of various research undertakings, our job is to generate tangible revenues to the university, not to facilitate research in someone's lab.

Moreover, because licensing for sponsored research involves early-stage or proof of concept technology in which market applications are still unclear, UTTO directors feel that they have to give substantial monetary discounts as incentives to their licensees. Finally, licensing for sponsored research might hinder the UTTOs eventual goals of licensing the technology to any other organizations, including new ventures and corporate partners.

[4] Petr Taborsky, an undergraduate student at the University of South Florida, invented a reusable cleanser that can remove ammonia from wastewater (U.S. Patent No. 5,082,813). He was later charged for theft and violation of probation for using his notebooks and for refusing to sign over his patent to the school. This bright student was eventually incarcerated with drug dealers, robbers, and sex offenders.

4.2.2. Licensing for equity

Our interviewees noted that this strategy is usually paired with proof of concept or reduced to practice technologies. The data show that approximately 17% of the UTTOs we studied used this as their predominant licensing strategy. The financial flexibility afforded by this arrangement allows the technology partner, which is a startup venture in two-thirds of the cases, to bring emerging technologies more quickly to market.

As one UTTO director from a private Mid-Atlantic university explained:

> . . . [with] early stage technologies, sometimes taking an equity stake in a company is the only way to get the technology out the door . . .

Our informants explained that large or resource-rich firms are less interested in proof of concept or reduced to practice stage technologies because of internal rate-of-return requirements on R&D investments. Additionally, given the inherently low success rate and relatively small commercial impact, a large corporation would view the bureaucratic process of managing a complex relationship with a university economically prohibitive.

Under this licensing strategy the UTTO treats the technology asset as a real option (McGrath, 1997). By investing in what is really a private partnership to further develop the technology, UTTOs bet also on the venture, rather than only on the technology. The objective is to support and harness the energy, aspiration, and motivation of the venture's scientists and founders to create a commercial application from IP. For this reason, UTTOs either leverage their endowed resources (e.g., Boston University, Harvard, and Stanford) with respect to latent incubator capacity (i.e., potential projects for incubators), or create their own incubators in the form of university-affiliated or government-sponsored Research Parks (e.g., RPI, University of Michigan, Cornell University). This explains why some UTTOs may even encourage their licensees to join their local incubator, which provides valuable resources in the form of managerial know-how and skills, business contacts, and social legitimacy (Link et al., 2003). As one UTTO director from a private Northeastern university explained:

> . . . taking equity in a firm is a way to legitimize the firm, but sometimes more importantly, to legitimize the technology. Incubators also help in this regard . . .

In fact, 62% of the institutions we studied have devoted significant resources into building business incubators that function as complements to and ''accelerators'' of technology commercialization efforts.

If the bet pays off and the venture successfully launches and makes sales, the university benefits as a claimant to the generated rents. If the venture reaches the stage of an IPO or some other exit pathway, the potential rents would be even higher; the university would enjoy income streams from a public firm while reallocating its resources for investments into other technologies and ventures. In such equity arrangements, the university loosens its control of the technology in exchange for future cash flow rights. In the event that the commercialization attempt is unsuccessful, the licensing agreement is usually terminated, which releases the technology back to the research institution, but hopefully at a more advanced stage, to be relicensed at a future time.

There are several advantages to this strategy in the proof of concept or reduced to practice technology stages (cf., Bray and Lee, 2000; Feldman et al., 2002). Informants explained that securing equity positions makes sense when the technology is unresolved, its economic implications are imprecise, and the opportunity costs of foregone licensing and royalty revenues are low. More specifically, real options theory suggests that equity is preferred as it confers licensors the opportunities for future financial gains once licensees develop the technology. Agency theory argues that equity positions in a company provide long-term incentives to align the interests of a university and the firm towards the common goal of commercializing the technology. Such incentive alignment might also mitigate uncertainty regarding IP-related litigations between licensors and licensees (Jensen and Thursby, 2001). Finally, university equity positions in startups send a signal on the university's confidence in the technology and its scientists to potential stakeholders including funding agencies, rivals, suppliers, and customers. Such confidence, so the rationale goes, increases the probability that licensees can secure additional funding, access key distribution channels, and more fully leverage the technology to generate rents.

The benefits of such licensing strategies to new ventures can be substantial. Startups benefit from university-based technologies because in the event of patent infringements, some of the legal burden may shift to the IP owner, which is the university.[5] As one UTTO director from a large Midwestern public research-based university emphasized,

> [The] new ventures we spin off often expect us to help them manage promising technologies ... and bear the risks early on in the technology's life cycle.

This point is particularly crucial for startups as infringement trial costs in 1997 reached $3 million for each party (Markman et al., 2004a). New ventures might also negotiate a first rights-of-refusal to cutting-edge proprietary technology with little or no transaction costs. Once an exclusive license is granted, startups enjoy some competitive insulation, while deriving legitimacy from its association with a university-based technology. Another benefit to new ventures is that as licensees they can tap more easily than ever into the knowledge, skills, and expertise of universities' scientists and students.

4.2.3. Licensing for cash

Our informants explained that since licensing choices are driven by the degree of technological resolution and future risk-return scenarios, licensing for cash is almost invariably paired with IP-based technologies at the *prototype* stage, for which a market has been identified. Since the expressed purpose of most UTTOs is to generate rents from scientific discovery, the more predictable the economic value, the more likely a UTTO will choose licensing for cash. Our data show that approximately 72% of the UTTOs in our sample used this as their predominant licensing strategy. A content analysis of UTTOs' mission statements corroborated this finding, as 80% of all mission statements highlight

[5] Since infringement cases are exceedingly expensive, universities always try to shift the legal burden to the licensee. For example, universities are less likely to file a lawsuit when the technology is licensed exclusively to a large, resource-rich corporation since the latter will have a natural incentive to protect its own rent streams.

licensing for cash as a key organizational objective. Interestingly, this is almost fourfold the times mission statements mention entrepreneurship or new-venture creation as their overarching goal (20.57%). Table 3 outlines the results of our content analysis of the UTTOs' mission statements.

The licensing for cash strategy is also frequently based on a technology that has not only demonstrated a clear path to commercialization but has also shown the potential for diverse applications that may span different industries. As one director from a large Southern public university that licenses primarily in the biotech and agribusiness domains observed,

> . . . highly applied discoveries in a single domain, for example, veterinary science, often find applications in other markets and this gives us more licensing opportunities.

Since the path to commercializing applied technology is less uncertain, industry partners are also more willing to license the IP. As licenses for cash are normally exclusive, they reduce some of the risks for the licensee. For instance, exclusive licensing agreements prohibit a UTTO from relicensing the same technology to others, and, naturally, such exclusivity attracts larger industry players. Exclusive licensing agreements for technologies at the prototype stage can generate the most rents and such agreements can be drafted to provide the greatest legal protection to the UTTO as the licensor. In one example, under exclusive licensing agreements companies were more willing to reimburse a UTTO for its IP-related costs, which sometimes exceeded $250,000, and to pay higher up-front fees. Furthermore, although the UTTO cannot relicense the technology, licensees as primary claimants were given the right to relicense to a third party, thus creating additional flow through rents to the UTTO.

Though no exclusionary rights—even those afforded by patents—provide unassailable protection, legal defense under exclusive agreements is simpler because the only parties to the licensing agreement are the UTTO and a single corporation. This strategy is also viewed as a risk-shifting arrangement for the UTTO. The large firm is the main beneficiary of the license and, because of this, also the risk bearer because it has to bear the nontrivial legal costs of protecting the technology.

Table 3
A content analysis of UTTO mission statements

Primary objectives of the UTTO	Percentage of times appeared in mission statement (%)
Licensing for royalties	78.72
IP protection/management	75.18
Facilitate disclosure process	71.63
Sponsored research and assisting inventors	56.74
Public good (disseminate information/technology)	54.61
Industry relationships	42.55
Economic development (region, state)	26.95
Entrepreneurship and new venture creation	20.57

$N = 128$ UTTOs.

As the UTTO director of a large West Coast private research university that specializes in IT-based discoveries reports,

> Exclusive licensing generally cuts up-front legal costs and lowers the carrying costs for the UTTO with respect to future legal action.

In addition to reducing legal costs, licensing for cash is also attractive in that the university can direct the resources to complete the technology commercialization cycle even when its technology partner chooses, for commercial reasons, not to bear the costs of final development. When the firm does choose to complete the commercialization process, the frequent engagement with the university's scientists to advance the technology can lead to substantial knowledge spillovers effects. As one UTTO director from a public Midwestern university explained:

> . . . often our scientists are keen to develop strong ties with industry partners in anticipation of future collaboration. When possible, we try to accommodate such requests.

Typically, because exclusive licensing arrangements are tightly defined around specifications of the licensed technology, the knowledge spillovers can result in future discoveries from which the university is free to exploit.

Taken as a whole, our fieldwork shows that while licensing for equity would be most conducive to new business formation, licensing for cash and for sponsored research would mostly likely be negatively related to new business formation. UTTOs in general would always try to license for cash. However, in terms of the other licensing strategies, we surmise from our fieldwork that (a) traditional UTTOs would most likely choose sponsored research and licensing for equity; (b) nonprofit structures would mostly likely avoid sponsored research; and (c) for-profit UTTO structures would mostly likely choose licensing for equity. Thus,

Proposition 2a: *Licensing for equity would be positively related to new business formation.*

Proposition 2b: *Licensing for cash and for sponsored research would be negatively related to new business formation.*

Proposition 3: *Traditional university UTTO structures would be positively related to sponsored research and equity strategies.*

Proposition 4: *Nonprofit UTTO structures would be negatively related to sponsored research strategy.*

Proposition 5: *For-profit UTTO structures would be positively related to equity strategies.*

5. Putting the model together

An important finding from our study is the correlation between UTTO structures, transfer strategy, and the creation of new ventures. The correlation matrix and descriptive statistics

Table 4
Correlation matrix among UTTO structures, licensing strategies, and startups

	1	2	3	4	5	6	7	8
1 Startups 1998–2001								
2 Startups in process	.67***							
3 University incubator	.07	.07						
4 Sponsored research	−.29***	−.13	−.17**					
5 License for cash	−.02	−.16*	−.09	−.53***				
6 License for equity	.30***	.37***	.24**	−.22**	−.56***			
7 Traditional structure	−.06	−.08	.37***	.19**	.10	.25***		
8 503(c) structure	.10	.01	.29***	−.15*	−.03	.11	−.86***	
9 For-profit extension	.19**	.17**	.16*	−.09	−.16*	.31***	−.26***	−.21**

$N = 128$ UTTOs.
*$P < .10$.
**$P < .05$.
***$P < .001$.

(Tables 4 and 5), culled from interview data and documents, suggest that the for-profit UTTO structure is positively related to the transfer of new technology via new venture formation. Although none of the other structures were correlated with venture creation, they were positively correlated with the presence of a business incubator.

The empirical data confirm that licensing for equity was positively related to new venture formation while licensing for sponsored research was negatively related to new venture formation. Interestingly, the licensing for sponsored research strategy was even negatively correlated with the existence of a university-based business incubator. Another and probably most important finding is that the licensing for cash strategy—the most prevalent UTTO

Table 5
Descriptive statistics

	Mean	Median	S.D.	Range
UTTO structure (1-0)				
Traditional structure	0.52	1.00	0.50	1.00
501(c) foundation	0.41	0.00	0.49	1.00
For-profit extension	0.07	0.00	0.23	1.00
Licensing strategy (%)				
Sponsored research	11	10.00	10.22	40.00
Equity	17	15.00	10.87	50.00
Cash	72	75.00	14.62	100.00
Incubator? (yes/no)	0.62	1.00	0.49	1.00
Average number of startups/university				
In 2001	3	2	4	26
In 2000	3	2	4	31
In 1999	2	1	3	19
In 1998	2	1	3	17

Data sources: AUTM, interviews, UTTO and university websites, UTTO internal documents
$N = 128$ UTTOs.

commercialization strategy—is the least related to new venture emergence. This observation suggests that licensing for cash strategies target mature and resourceful corporations rather than new ventures. This finding is also consistent with UTTO mission statements that emphasize royalties and underemphasize entrepreneurship.

The relationships between UTTO structures and licensing strategies are also interesting. For example, both the traditional and the nonprofit structures are related to licensing strategies that favor sponsored research; however, the former is positively whereas the latter is negatively related. On the other hand, both the traditional university and for-profit structures are positively related to licensing strategies that are more likely to lead to the creation of new ventures. Coincidentally, although one might expect the for-profit UTTOs to seek primarily cash strategies, the correlation matrix does not support this expectation. In fact, as stated above, it appears that the for-profit UTTOs, perhaps due to their focus and personnel's experience in business development, are best positioned to provide strong support for new business creation. As one UTTO director who managed a for-profit UTTO noted:

> . . . when I hire personnel, I am looking for them to have worked for a VC or to have other business development experience.

Our interviews also found an important association between technology stage, transfer strategy, and the choice of licensees. Summarized in Fig. 1, the theoretical model illustrates that early-stage inventions are licensed, primarily through sponsored research, to large firms. Large firms are also the primary recipients of technologies at the prototype stage, transferred through cash strategies. In contrast, new ventures are the primary licensing targets of technologies at the proof of concept stage or those that have been reduced to practice.

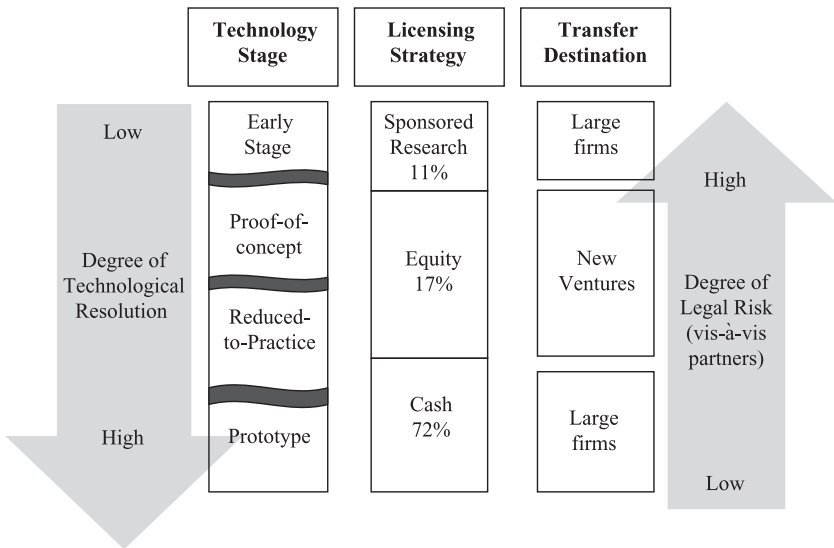

Fig. 1. The relationship between technology stage, licensing strategy, and transfer partner.

6. Discussion and conclusions

Taken together, these findings suggest that universities most interested in generating short-term cash flows from their IP licensing strategies are least positioned to create long-term wealth through venture creation. Although two-thirds of the universities in this study have invested significant resources in incubators and have expressed an interest in new business startups and economic development, most of them have not linked this to their technology transfer strategy choices or to the mission of their UTTOs. This disconnect may be one reason why university incubators tend to remain at the fringe of regional economic development efforts, in spite of the espoused goals of community development in many university mission statements. As one UTTO director from a private Midwestern university remarked:

> ... despite the pressures from the state to focus on local business development, I feel obligated to get the best deal I can for the university [and the administration] ...

To reiterate, this paper was motivated by several gaps in the literature. The various structures by which research institutions house their technology transfer functions, licensing strategies to commercialize proprietary technology, and their links to new venture emergence have thus far been relatively unexplored. Moreover, there has been little theory development vis-à-vis UTTO structures, strategy, and new venture formation. Our paper addressed this gap with the near-census survey of U.S. research universities actively involved in technology transfer activities and, using a grounded theory approach, developed a model to explain the relationships between UTTO structures, licensing strategies, and new venture formation.

Our resulting model argues that for-profit UTTO structures and licensing in exchange for equity are most positively related to new venture formation. More importantly, our model shows that traditional and nonprofit UTTO structures are unrelated to new ventures even though they are correlated with the presence of a university business incubator. Licensing in exchange for sponsored research is negatively related to new venture formation. Interestingly, we also found that licensing for cash—the transfer strategy of choice among 72% of UTTOs we studied—is least related to new venture creation, a disconcerting finding given that the universities in which they operate have overwhelmingly invested in incubators to accelerate new venture creation.

Taken as a whole, this study contributes to theory in several ways. First, with the exception of insightful but narrow case studies there is currently no general framework for understanding the links between UTTO structure, licensing strategies, and new firm creation. Preliminary notions of this process may be found in the technology and knowledge transfer literature (cf., the specialized journals we mentioned earlier), with much of this research providing valuable insight on knowledge flow and spillovers from universities to industry (cf., Agrawal and Henderson, 2002; Jaffe et al., 1993; Link et al., in press) and vice versa (Cohen et al., 1998). However, the adjunct processes of technology transfer to new startups are still poorly understood. Second, our study provides rich insights on the precise structures of UTTOs and proposes a model that *simultaneously* includes UTTO strategies, structures, and technology transfer outcomes. More importantly, based on our near-census data

collection technique, we assume that we have described the phenomenon as well as one can reasonably expect with the inherent shortcomings of the long interview.

From a public policy standpoint, taxpayer support for university basic research is traditionally justified by a return-to-society on investment argument (Jensen and Thursby, 2001). Therefore, universities are pressured to show tangible returns for the research grants they receive. Universities that excel at managing proprietary technologies command healthy royalty income streams, which reduce the public burden as taxpayers. For example, in 1999 Columbia University reported over $95 million in gross licensing revenues, with much of it from equity returns. This fact is important as our interviews revealed that U.S. universities' attitudes toward equity can range from policies that are hostile toward equity, to cautious acceptance of equity when cash strategy is ineffective, to aggressively seeking equity whenever possible. For example, as one UTTO director from a private Midwestern university remarked:

> . . . the legislature has recently changed the law permitting us to take equity in companies. I am working on my first contract and will aggressively seek equity deals. Some of my colleagues are being more cautious.

Indeed, research has shown that in the long run taking equity in startups produces a greater rate of return than the average cash license arrangement (Bray and Lee, 2000). Others report that UK universities with clearer strategies towards the spinning out of firms and the use of surrogate entrepreneurs in this process are more successful at generating cash flows from their licensing activities (Franklin et al., 2001; Lockett et al., 2003). Our model extends such studies as it helps to define a framework for studying the efficacy of UTTOs' licensing strategies in creating new ventures.

The substantial growth in universities' patenting and licenses activity has prompted policymakers to debate the possible "unintended" effects of the Bayh–Dole Act, such as the apparent shift toward applied research in place of basic research. More specifically, our findings that universities employ different UTTO configurations with varying levels of autonomy could raise concerns that expectations of financial returns would, over time, increase the allocation of capital to applied research and reduce the capital to basic research. Although we report that licensing for cash is the predominant licensing strategy, we note that none of the UTTO structures are statistically significantly related to the cash strategy. In fact, we found that the for-profit structure was even marginally negatively related to this licensing strategy. Also, research has shown that the decrease in average proportion of basic research to total research expenditures between 1977–1980 and 1994–1998 was only 0.005 (Thursby and Thursby, 2002). Thus, the "problem" of a shift from basic to applied research may be overstated, at least in reference to universities' technology licensing strategies.

It has been further suggested elsewhere that the role of the UTTO is "not to develop links between the university and industry, but rather to monitor, facilitate, and regulate the transactions between parties" (Colyvas et al., 2002, p. 65). Our findings challenge this notion as we found that UTTOs play a key role in economic development by adopting various structural configurations and enacting different transfer strategies that appear to correlate with

varying levels of new venture formation. Having said this, we have to wonder why licensing for cash was such a predominantly favored strategy. Interviewees explained that since universities are unlikely to thrive unless they recover their R&D and UTTO administration costs, research institutions are increasingly looking at technology commercialization as a source of recurring revenues. Indeed, in an era of budget cutbacks, ensuring healthy operational cash flows has become an important objective for universities. However, the problem of incongruence between incentive systems and goals, which has been noted in previous research (Kerr, 1975) and which we rediscovered in this study, means that universities must remain watchful over the potential trade-offs and conflicts between technology dissemination and revenue generation (Markman et al., 2004b).

Finally, we found that universities are increasingly viewing themselves as catalysts of new venture formation and regional development. As one UTTO director from a public Midwestern university explained:

> . . . more and more university administrators have realized that focusing on local economic development can buy a lot of political capital as well as research funding from the state . . .

Perhaps this is the reason why 62% of the universities in our sample are establishing business incubators and building research parks in their communities. These are ways to encourage technology-based new ventures and subsequent economic development (Link et al., 2003). With the exception of such institutions as Harvard, Boston University, Stanford University, and the like who were already part of new venture "nurseries" or regional ecologies of emerging organizations, many of our informants told us that those universities without incubators were planning to build one. What we found in this study is that although licensing for equity is more likely to drive new venture emergence, the UTTO motivation to maximize cash flows and minimize financial and legal risks often lead to a strategic choice that does not support new venture creation.

7. Limitations

Most social science research is inherently incomplete, and our study is clearly no exception. For example, although our sample of 128 research universities reflect a 92% response rate, it is restricted to U.S. universities and it does not represent the total population of all research institutions, which may include government research laboratories such the National Institutes of Health (NIH) and the National Institute for Standards and Testing (NIST). However, our sample accounts for over 60% of federal and industry research dollars, and over 70% of licenses executed, inventions disclosures, and new patent applications (cf., Thursby and Thursby, 2002) and so we are confident that our model captures the full phenomenon as far as research-based U.S. universities are concerned. Still, future research on this topic would benefit from studies based on broader sample, including non-U.S. institutions.

Our research design cannot ascertain causality. For example, we cannot tell if licensing strategies or UTTO structures are driven by past UTTO performance, institutional shift

towards applied research with strong commercial appeal, or by an increase in demand for university contracts because of cutbacks in industry R&D. This suggests that future studies on this topic, which would involve large sample panel data, should attempt to control for universities' research orientation, industry behavior, and the effect of time.

Nonetheless, the use of interviews and a grounded theory approach has several advantages over previous attempts to document UTTO activities. Attributing meaning to actions and behaviors based on secondary data, mere observation, or without interacting with the UTTO directors can lead to gross misunderstandings (de Vaus, 2001). For example, almost all the universities in our sample have websites explaining the role and work of their technology transfer offices. However, without contextualizing this information with interviews, it would appear that all UTTOs are equally sophisticated in their strategies and successful in what they do. We found differently. With interviews, meanings that resided only in and between the informants are surfaced, giving the researchers a better understanding of the nature of the data. In the context of our study, interviewees gave rich and logical accounts of the decisions and organizational processes within a narrowly defined contextual field. As such, our design and interviews seemed to have achieved a reasonable level of internal, face, and construct validity. Although interview data lack statistical generalizability, we feel the limitations are acceptable because our primary goal was theory building rather than theory testing.

In closing, our paper applies grounded theory to glean insights into the links between UTTO structures, licensing strategies, and new venture creations. Findings indicate how UTTOs are structured, how technological discoveries are categorized, the licensing strategies utilized, and their link to startups. It is our hope that the findings and approach used here will spur other researchers to further elaborate, perhaps longitudinally, which UTTO structure and licensing strategy combinations are more conducive for the creation of new firms.

Acknowledgements

This paper benefited from comments made by the members of the Terry College of Business Brown Bag Seminar (October 2002) and the participants of the RPI conference (April 2003). We also thank Ann Buchholtz, Eileen Fischer, Michael Lubatkin, two anonymous reviewers, and the special issue editors for their insightful comments and suggestions. We acknowledge with gratitude the financial support for this study from the Department of Management at the Terry College of Business and from the John Broadbent Endowment for Research in Entrepreneurship at Rensselaer Polytechnic Institute.

References

Agrawal, A., Henderson, R., 2002. Putting patents in context: exploring knowledge transfer from MIT. Manage. Sci. 48, 44–60.

Association of University Technology Managers, 2000. The AUTM Licensing Survey: Fiscal Year 1999. Association of University Technology Managers, Norwalk, CT.

Association of University Technology Managers, 2002. The AUTM Licensing Survey: Fiscal Year 2000, Survey Summary. Association of University Technology Managers, Norwalk, CT.
Bray, M.J., Lee, J.N., 2000. University revenues from technology transfer: licensing fees vs. equity positions. J. Bus. Venturing 15, 385–392.
Cockburn, I., Henderson, R., 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. J. Ind. Econ. 46 (2), 157–182.
Cohen, W., Florida, R., Randazzese, L., Walsh, J., 1998. Industry and the academy: uneasy partners in the cause of technological advance. In: Noll, R. (Ed.), Challenges to the Research University. Brookings Institution, Washington, DC.
Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R.R., Rosenberg, N., Sampat, B.N., 2002. How do university inventions get into practice? Manage. Sci. 48, 61–72.
Creswell, J.W., 2002. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 2nd ed. Sage, Thousand Oaks, CA.
de Vaus, D.A., 2001. Research Design in Social Research. SAGE, London.
Eisenhardt, K.M., 1989. Building theories from case study research. Acad. Manage. Rev. 14, 532–550.
Feldman, M., Feller, I., Bercovitz, J., Burton, R., 2002. Equity and technology transfer strategies of American research universities. Manage. Sci. 48, 105–121.
Flint, D., Woodruff, R., Gardial, S., 2002. Exploring the phenomenon of customers' desired value change in a business to business context. J. Mark. 66, 102–117.
Franklin, S., Wright, M., Lockett, A., 2001. Academic and surrogate entrepreneurs in university spin-out companies. J. Technol. Transf. 26, 127–141.
Glaser, B.G., Strauss, F., 1999. The Discovery of Grounded Theory: Strategies for Qualitative Research Aldine De Gruyter, New York.
Holstein, J.A., Gubrium, J.F., 1995. The Active Interview Sage, Thousand Oaks, CA.
Jaffe, A., Henderson, R., Trajtenberg, M., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. Q. J. Econ. 108, 577–598.
Jensen, R., Thursby, M.C., 2001. Proofs and prototypes for sale: the tale of university licensing. Am. Econ. Rev. 91, 240–259.
Kerr, S., 1975. On the folly of rewarding A, while hoping for B. Acad. Manage. J. 18, 769–783.
Link, A.N., Scott, J.T., Siegel, D.S., 2003. The economics of intellectual property at universities: an overview of the special issue. Int. J. Ind. Organ 21, 1301–1322.
Lockett, A., Wright, M., Franklin, S., 2003. Technology transfer and universities' spin-out strategies. Small Bus. Econ. 20 (2), 185–200.
Markman, G.D., Espina, M.I., Phan, P.H., 2004a. Patents as surrogates for inimitable and non-substitutable resources. J. Manage. 30, 529–544.
Markman, G.D., Gianiodis, P.T., Phan, P.H., Balkin, D.B., 2004b. Entrepreneurship from the ivory tower: Do incentive systems matter? J. Technol. Transf. 29, 353–364.
McGrath, R.H., 1997. A real options logic for initiating technology position investments. Acad. Manage. Rev. 22, 974–996.
Mowery, D.C., Shane, S., 2002. Introduction to the special issue on university entrepreneurship and technology transfer. Manage. Sci. 48 (1), v–ix.
Schumpeter, J.A., 1950. Capitalism, Socialism, and Democracy Harper, New York.
Shane, S., Venkatramanan, S., 2000. The promise of entrepreneurship as a field of research. Acad. Manage. Rev. 25, 217–226.
Siegel, D., Waldman, D., Link, A.N., 2003. Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study. Res. Policy 32 (1), 27–48.
Siegel, D., Waldman, D., Atwater, Link, A.N., 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. J. Eng. Technol. Manage. 21, 115–142.

Small Business Association, 2002. The Influence of R&D Expenditures on New Firm Formation and Economic Growth. BJK Associates, Maplewood, NJ.

Strauss, A., Corbin, J., 1998. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, 2nd ed. Sage, Thousand Oaks, CA.

Thursby, J.G., Thursby, M.C., 2002. Who is selling the ivory tower? Sources of growth in university licensing. Manage. Sci. 48, 90–104.

Thursby, J.G., Jensen, R., Thursby, M.C., 2001. Objectives, characteristics, and outcomes of university licensing: A survey of major U.S. universities. J. Technol. Transf. 26, 59–72.

Zucker, L., Brewer, M., 1998. Intellectual capital and the birth of U.S. biotechnology enterprises. Am. Econ. Rev. 88, 290–306.

Zucker, L., Darby, M., Armstrong, J., 1998. Intellectual capital and the firm: the technology of geographically localized knowledge spillovers. Econ. Inq. 36, 65–86.