Higher Education **29**: 369–384, 1995.

University–industry entrepreneurship: the organization and management of American university technology transfer units

DAVID D. DILL
Public Policy Analysis and Education, University of North Carolina at Chapel Hill, U.S.A.

Abstract. Mechanisms for increasing technology transfer between universities and industry have proliferated rapidly in the United States as institutions of higher education have become much more entrepreneurial. The economic implications of these activities have received substantial attention and the sociological aspects of this process have been vigorously debated (e.g., the effect of university–industry relationships on academic integrity). Much less consideration has been given to the successful organization and management of these emerging university 'service' units. The study presents results of a national survey of the organization, management, and perceived performance effectiveness of university technology transfer units. Units studied included: licensing and patenting offices (units seeking commercial applications for university research); small business development centers (units providing technical or managerial assistance to entrepreneurs or small businesses); research and technology centers (units operating or participating in facilities for the development of new technology); incubators (units managing facilities in support of new technology-based businesses); and investment/endowment offices (units utilizing the university's financial resources for equity in start-up businesses). The implications of the research for university management and government policy are explored.

Introduction

American higher education has long been noted for its innovative capacity, particularly in the application of research to national needs and commercial activities (Clark 1983). Federal subsidies for agricultural research and extension services at American universities have generally been acknowledged as providing American agriculture certain comparative advantages (Geiger 1988). Following World War II a number of American universities extended this model into research collaborations with business and industry. In the 1980s these university–industry relationships mushroomed into a complex array of research consortia, research parks, and industrial liaison programs (Peters and Fusfeld 1983).

American universities are said to have now entered a new 'entrepreneurial' phase of university–industrial relationships characterized by a revolutionary change from research production toward commercialization of faculty members' research (Geiger 1992). This development has been encouraged by Federal government agencies and state legislatures interested in utilizing university research expertise to foster economic competitiveness. Thus the National Science Foundation has supported industry–university alliances through its program of engineering research centers (Mayfield and Schultzman 1987), and state projects such as the Edison program in Ohio and the Ben Franklin Partnerships in Pennsylvania have encouraged collaborations between industry and universities to form new companies (Smith and Drabenstott 1992). Universities have also been lured by the potential of substantial earnings from the commercialization of their research activities. Revenues from research royalties and licensing fees, such as those reported in 1987–88 by Stanford ($9.1 million), the University of California ($5.4 million), and the University of Wisconsin ($5 million), have encouraged research universities to seek more active mechanisms of technology transfer (Feller 1990). These new mechanisms include industrial incubators to develop new companies, venture capital experiments in support of university technology, and more innovative licensing and patenting efforts.

The early literature of university–industry relationships focused on their possible influence on economic development (Peters and Wheeler 1988), as well as their potential negative impact on the core function of teaching (Fairweather 1989) and on the academic integrity of the university (Stankiewicz 1986). More recently attention has turned to questions regarding the means by which these relationships can be organized and managed in order to foster effective technology transfer (Tornatzky and Fleisher 1990).

The management of university–industry relationships can be understood as a special instance of the process of technology transfer (Dill 1990). While most research on technology transfer has focused on intra-organizational processes, university–industry research relationships represent the even more challenging effort of inter-organizational technology transfer. How university technology transfer units are organized, how they are managed, and what factors account for successful performance in such units is therefore of both theoretical and practical interest.

As other countries seek to reform their systems of higher education, in part to make them more significant instruments of economic development, the changing relationship between universities and industry in the United States has become an object of intense interest among the international community of policy makers and university leaders. Therefore, this study reports on a national survey of university technology transfer units in the United States. The survey focused on the incidence of these units in the American higher education system, characteristics of their organization, funding and management, as well as the relationship between measures of organization and management and perceived unit performance.

Definitions

University technology transfer is defined as formal efforts to capitalize upon university research by bringing research outcomes to fruition as commercial ventures. Formal efforts are in turn defined as organizational units with explicit responsibility for promoting technology transfer. Historically, for example, some research universities have had active licensing and patenting offices to broker university developed technology and to license services, as well as units to provide technical assistance to existing companies and new businesses (Peters and Fusfeld 1983). Many universities have also developed organized research units in particular technical fields under industry support (Geiger 1990). What characterizes the current environment of American higher education is the rapid diffusion of these mechanisms to other universities, and the adoption of even more entrepreneurial techniques (Fairweather 1988). Following a review of relevant literature (Fairweather 1988, Larsen and Wigand 1987, Peters and Fusfeld 1983), the following definitions for technology transfer units to be directly included in this study were developed:

- Licensing and Patenting Offices (Example: Office of Patents, Copyright and Licensing, Harvard University) – units responsible for assisting faculty members and/or the university in obtaining patents, selling licenses, and seeking commercial outlets for research.
- Small Business Development Centers (Example: Small Business Development Center, University of Iowa) – units responsible for providing technical assistance for new business start-ups or technical support in management, new product development, and process innovation to existing companies.
- Research and Technology Centers (Example: Advanced Technology Center, SUNY Stony Brook) – units responsible for stimulating research and technology transfer in a particular area of technology, usually under joint university–industry support.
- Incubators (Example: BioTech Incubator, University of Colorado Health Sciences) – units responsible for providing facilities and/or services to multiple businesses in a related field of technology.
- Endowment/Investment Activities (Example: Office of Research and Technology Transfer, University of Minnesota) – units responsible for investing the university's financial resources in start-up companies or spin-off enterprises based upon university technology. These funds may be invested directly or through separately incorporated corporate affiliates.

The American system of higher education, in which technology transfer activity occurs, includes over 3,000 accredited institutions. These institutions can be reliably classified by means of control, i.e., public and private, and by function, i.e., doctorate-granting institutions, comprehensive universities, liberal arts colleges, two-year institutions, and specialized institutions (Carnegie Foundation for the Advancement of Teaching 1987). The validity of these classifications has been well established by research relating functional differences among institutions to variations on measures of academic governance, faculty activity, and research productivity (Baldridge *et al.* 1978, Clark 1987). Universities which grant the doctorate and specialized institutions engaged in engineering and health-related work account for the vast majority of federally and privately sponsored research conducted in American academic institutions. Therefore these types of institutions were selected as the population base for the study. Table 1 lists the total number

Table 1. American university population*

	(n = 289)
1:	Research Universities Type 1 (n = 70) Examples: • Harvard University • Stanford University • University of California, San Diego • University of Minnesota
2:	Research Universities Type 2 (n = 33) Examples: • Brown University • Georgetown University • University of Delaware • University of Kansas
3:	Doctoral Granting Universities (n = 109) Examples: • Dartmouth College • Saint Louis University • Clemson University • Illinois State University
4:	Medical and Engineering Schools (n = 77) Examples: • Mayo Foundation, Mayo Medical Center • New England Institute of Technology • University of Colorado, Health Sciences • South Dakota School of Mines and Technology

*Derived from the Carnegie Classification of Higher Education (Carnegie Foundation for the Advancement of Teaching, 1987).

(n = 289) of universities by Carnegie classification used for this study and provides examples of the institutions in each category.

Sample

Based upon the population described above a stratified random sample of 115 institutions was drawn representing 39.7% of the overall population (Table 2). The chief business officer of each of the sample institutions was contacted by phone and asked a series of questions regarding the existence of technology transfer units on his or her campus, and the name and address of the head of each unit. The overall response rate to this telephone survey was 78%, or 90 institutions. Table 2 summarizes the population sampled, the total sample and the number of responses by university type. Note that in addition to the high overall response rate of 78%,

Table 2. Composition of sample

Proportion of University Population Sampled

Univ. Type	Population	Total sample	% of total
1	70	43	61.4%
2	33	20	60.6%
3	109	29	26.6%
4	77	23	29.8%
	289	115	39.7%

Response rate

Univ. Type	Total Sample	# of Resps.	Response rate
1	43	33	76.7%
2	20	14	70.0%
3	29	24	82.7%
4	23	19	82.6%
	115	90	78.0%

Proportion of University Type for population, total sample, and responses

Univ. Type	Population	Total Sample	# of Responses
1	70 (24.2%)	43 (37.4%)	33 (36.7%)
2	33 (11.4%)	20 (17.4%)	14 (15.6%)
3	109 (37.7%)	29 (25.2%)	24 (26.6%)
4	77 (26.7%)	23 (20.0%)	19 (21.1%)
	289(100.0%)	115(100.0%)	90(100.0%)

the percentage of response among each of the four university types sampled ranged from 70% to 82.7%. This suggests that with regard to type of institution, the sample is reflective of the overall population.

Incidence of university technology transfer units in the United States

Utilizing reported information on the distribution among the university types of the five categories of technology transfer units (see definitions above) in the representative sample, estimates were then calculated of the incidence of these units among university types in the total population (Table 3). To provide a basis for comparison, an expected population value was calculated by multiplying the estimated total of each category of technology transfer unit by the proportion of institutions composing each university type in the overall population.

As Table 3 suggests, the estimated incidence of all five categories of technology transfer activity is greater in the Research University I institutions (Type 1) than would have been expected from their proportion of the total population. This is particularly so for the more entrepreneurial activities such as patenting and licensing, incubators, and investment/endowment activities. The smaller Research

Table 3. Estimated and expected incidence of American technology transfer units by university type*

Univ. Type	Lics/Pats	Small Bus	R&T Cents	Incubators	Invest/End
1	70 *(53)*	49 *(47)*	28 *(26)*	30 *(14)*	15 *(6)*
2	28 *(25)*	21 *(22)*	12 *(12)*	5 *(7)*	2 *(2)*
3	68 *(83)*	86 *(72)*	36 *(41)*	9 *(23)*	5 *(8)*
4	53 *(58)*	36 *(51)*	32 *(29)*	16 *(16)*	0 *(6)*
	219 *(219)*	192 *(192)*	108 *(108)*	60 *(60)*	22 *(22)*

(Expected incidence in italics)

*Respondents also reported owning, operating or affiliating with a research park (n = 34, or 37% of respondents), and receiving money for joint university–private sector research projects (n = 73, or 81% of respondents). See text.

Universities II (Type 2) are involved in technology transfer activity to the extent expected. The large number of Doctoral Granting Universities (Type 3) appear to be more committed to business assistance and consulting activities (i.e., small business development) and less involved than expected in entrepreneurial activity, reflecting perhaps their lower intensity of involvement in basic research. Conversely, Medical and Engineering Schools (Type 4) are at the expected level in entrepreneurial activities, save they are late starters in exploring the potential of venture capital activities for stimulating technology transfer. Consistent with their academic specialization and strong research orientation, they are also less engaged in small business development activities than would be expected by their proportion in the overall population.

Respondents were also asked about ownership, operation, or affiliation with a research park. Thirty four (37%) of the respondents reported such units, but they were not included in this survey because these research units were the subject of a separate study. Seventy three (81%) of the respondents also reported receiving money for joint university–industry research agreements or projects, but these activities were scattered among many schools or departments and were often independent of administrative units committed to technology transfer.

Based upon responses to the telephone survey, separate questionnaires were sent to the reported heads of each of the five categories of university technology transfer units. The rest of this paper addresses items on organization and management common to all five questionnaires.

Measures of organization and management

The process of technology transfer has come to be understood as an interactive sequence of information processing activities during which various functional units actively participate in reducing the uncertainty of innovation (Allen 1985). Studies of the organization and management of technology transfer have suggested that effective performance is influenced by individual factors (e.g., the background and orientation of managers), managerial factors (e.g., the communication behavior of managers), and organizational factors (e.g., unit age, size, and financial resources) (De Meyer 1985, Keller 1986). Consequently, measures of all three of these factors were included in the study as independent variables.

Organizational factors examined for each technology transfer unit included the year of founding for the unit, the number of professionals (FTE), the number of support staff (FTE), and the most recent annual budget. Individual factors, requested from the manager of each unit, included his or her birth date, terminal degree, field of study, and years of experience in both the relevant field and in the university setting. These latter questions were motivated by consistent evidence in the R&D literature that managerial technical expertise and experience are correlated with organizational performance (Dill 1985). In addition, the orientation of managers, whether to advancement as a manager, or to professional development as a scientist, has been shown to influence the effectiveness of technology transfer activity (Raelin 1986). Consequently two Likert scale items of professional orientation – orientation to technical/functional work and orientation to general management – were developed from Schein's (1978) research on 'career anchors' and included in the study. Managerial factors included in the study, derived from previous research on technology transfer performance, included time spent on various managerial tasks (i.e., proportion of time managers spent on administration, research, teaching, and consulting in their present positions) as well as managers' span of control (i.e., number of people supervised). In keeping with the consistently significant findings on the centrality of information processing and communications activity to the management of technology transfer (Allen 1985, De Meyer 1985), four Likert scale items were also included on the frequency of managerial communication at the unit, university, local community, and national levels.

A central problem in research on technology transfer is means of identifying and measuring performance (Van de Ven 1986). Direct measures of the outputs of technology transfer are rare in the literature because of the long time lags between research discovery and product launch. As a result, research in the field traditionally uses interim proxy measures such as publications, citations, patents, return on investment, and perceptions of performance (Keller 1986). In the current instance, the problem is further complicated by the relative newness of many of the units studied, and the variations in function among them. Studies of organization and management which fail to include performance measures, however, are of limited value. Therefore, each manager was asked to rate their unit/department's overall performance. This measure was then used as a dependent variable to evaluate the relevance of the individual, managerial, and organizational variables to technology transfer.

Results

The analysis of the survey responses focused on the organizational characteristics of the various types of units (Table 4), the background of technology transfer unit

Table 4. Organizational characteristics of university technology transfer units

	Lics/Pats (n = 42)	Small Bus (n = 24)	R&T Cents (n = 5)	Incubators (n = 4)	Invest/End (n = 4)
Years old					
Mean	11.36	10.16	3.25	8.75	*
Range	1–49	1–24	1–5	1–27	*
Full-time equivalent professionals					
Mean	2.90	4.1	9.0	50.5	9.75
Range	0–20	0–17	0–25	0–200	3–25
Full-time equivalent support					
Mean	2.3	2.2	14.6	.75	5.0
Range	0–19	0–6	0–45	0–2	1–16
Annual budget					
Mean	$307,216	$508,451	$1.7 M	$5.1 M	$1.5 M
Range	$20,000– 2 M	$3200– 3.1 M	$20,000– 8 M	$0–20 M	$180,000– 3.5 M

*Data not available.

managers (Table 5), and the individual, managerial, and organizational correlates of perceived unit performance (Table 6).

Organizational characteristics

Consistent with previous surveys, both licensing and patenting units, and small business development centers were found to be the most numerous technology transfer mechanisms and the most long-lived (Table 4). By contrast, most of the research and technology centers, investment/endowment activities, and incubators have been started in the last five years (one incubator facility which has been in existence for 27 years, markedly affected the average age of these facilities). The incidence of 0 values in all units except investment/endowment is due to a number of new technology transfer units which were just beginning, further supporting the view that this field is still very dynamic. Licensing and patenting offices, small business development centers, and investment/endowment activities tend to be relatively small administrative units ranging from an average of 5 to 15 professional and support personnel with budgets of up to $3 M. By contrast research and technology centers as well as incubators require substantially larger staffs and corporate size operating budgets ranging up to $20 M. The incubators in particular are staffed primarily by professionals. In both these latter cases, the units

Table 5. Background of university technology transfer managers

(n = 80)		
Terminal degree:		
PhD	35	43.7%
Other doctorate (e.g., JD/MD)	6	7.5%
Masters	20	25.0%
Bachelors	16	20.0%
High School	1	1.3%
Other	2	2.5%
	80	100.0%
Field of study:		
Natural science	14	17.5%
Physical science	8	10.0%
Social science	4	5.0%
Engineering	7	8.8%
Law	5	6.2%
Business/public administration	30	37.5%
Other	12	15.0%
	80	100.0%

more clearly approach corporate R&D facilities in their organization and management.

Individual backgrounds

The backgrounds of the managers of these technology transfer units reflected an expected split between professional managers and scientists (Table 5). Slightly more than half of the managers had a doctoral degree; the largest single group majored in business or public administration. Only 35% of the managers were specialists in the natural and physical sciences or engineering. It is worth noting, however, that the largest number of respondents were from licensing and patenting offices and small business development centers.

Correlates of perceived performance

Simple correlations were calculated for the individual, managerial, and organizational variables previously described (Table 6). While there were observable and consistent correlations between the organizational variables and perceived unit performance, none of these correlations was significant. These relationships suggest that perceived performance was not simply a function of unit size or budget.

In contrast, the correlations of individual characteristics of managers with

Table 6. Individual, managerial, and organizational correlates of perceived university technology transfer unit performance

	(n = 80)
Individual variables:	
Age	.20
Years of experience in the field	.30**
Years of experience in university	.03
Terminal degree	.02
Technical orientation	.23*
Managerial orientation	.18
Managerial variables:	
Time spent on administration	−.04
Time spent on research	−.16
Time spent on teaching	.01
Time spent on consulting	.15
Number of individuals supervised	.05
Frequency of unit communication	.37***
Frequency of university communication	.30**
Frequency of local community communication	.37***
Frequency of national communication	.26*
Organizational variables:	
FTE professionals	.16
FTE support staff	.16
Annual budget of unit	.18

*p < .05
**p < .01
***p < .001

perceived performance revealed some significant relationships. There was no observable correlation between number of years of education (terminal degree) and perceived performance. In a separate Chi Square analysis, there was also no significant relationship between field of study and perceived unit performance. In contrast, years of experience in the relevant field of expertise (but note, not in the university), was significantly correlated ($p < .01$) with perceived unit performance. This finding is consistent with a body of research in industrial R&D settings in which relevant experience is related to managerial performance (Dill 1985). The significant relationship ($p < .05$) between technical orientation and perceived unit performance also gives some support to the role of professional expertise in the effective management of technology transfer activities. 'Technical orientation' in this context is not necessarily equivalent to 'scientific orientation.' Rather in Schein's (1978) formulation, it relates to whether an individual manager is orientated towards the intrinsic interests of the field itself (e.g., licensing and patenting), or towards the attractions of general management.

The most significant relationships were between managerial factors and perceived performance. There was only a negligible correlation between number of individuals supervised and unit performance, again suggesting that unit size is not a critical variable. With the exception of time spent on consulting, there were no observable correlations between how managers committed their time and unit performance. There was evidence from marginal comments in the survey questionnaires that 'time spent on administration' was interpreted by some respondents as 'bureaucratic paperwork,' thereby possibly biasing these results. However, there were very strong relationships discovered between perceived unit performance and the frequency of the manager's communication with other members of the unit ($p < .001$), and with members of the local business/industry community ($p < .001$). The relationship between perceived unit performance and the manager's frequency of communication with other personnel at the university ($p < .01$) and with members of the national business/industry community was also significant ($p < .01$), but less strongly so. These relationships are quite consistent with a long standing tradition of research in industrial research and development (Allen 1985). They suggest that individual and managerial factors found to correlate with R&D performance in industrial settings may be applicable to the design of technology transfer activities in universities, and that further, inter-organizational technology transfer involving universities and industry may be fruitfully explored by frameworks developed at the intra-organizational level (Souder 1987).

Implications

The results of the study confirm that American research universities have entered a new stage of 'entrepreneurial' or active technology transfer and that the scale of this activity is substantial. In addition to the early and still relevant criticisms regarding the effects of this activity on the academic integrity of universities, there is now a growing concern that university technology transfer programs engender significant overhead expenses (Geiger 1992). In the current competitive environment these expenses represent opportunity costs for academic and research programs. Feller (1990) has argued that there is a genuine danger of over-investment by universities in technology transfer: university administrators lack the experience to make accurate revenue and cost projections in these areas, they do not have the discipline of bottom-line profit structures to act as a brake on 'unprofitable' administrative activities, and the non-profit organization of universities provides few market signals to guide their decisions. These weaknesses can explain the surge of universities into entrepreneurial technology transfer activities, and would predict a slow rate of extrication from unprofitable situations. Conversely, a number of thoughtful advocates have argued that economic development in contemporary societies requires continued technological innovation and rapid conversion of innovations to quality products and processes (Dertouzos *et al.* 1990; Tornatzky and Fleisher 1989). Thus, they strongly endorse the increased interactions and collaboration among universities, industrial firms, and governmental agencies and applaud more active efforts of technology transfer between universities and industry.

Both of these latter perspectives require that we increase our knowledge about the organization and management of university technology transfer activities so that universities can continue to contribute to economic development while sustaining their essential functions of research and teaching. The current study provides some suggestions for this needed research as well as possible implications for policy. First the individual characteristics which correlated with perceived unit performance, experience in the field and technical orientation, are completely consistent with individual variables associated with successful managers of technology transfer in industry (Roberts 1989). This suggests that the traditional academic bias toward appointing experienced academics to head university administrative units, or conversely, placing general managers or lawyers in these positions, may be particularly unwise in the area of technology transfer and could contribute to the mis-investments suggested by Feller (1990). While administrative selections should be based upon individual merit in each case, experience in industrial R&D and technical competence appear to deserve special consideration in the selection of managers of university technology transfer units.

Second, the apparent importance of communication skills, both within the relevant unit and with external constituencies, is again consistent with a substantial body of research on industrial R&D (Allen 1985). This communication is two-way, not only exploring with external agencies the research potential of university discoveries, but also acting as a 'gatekeeper,' feeding relevant external information back to scientists within the university (Tushman and Katz 1980). The relevance of communication and networking skills may be even greater in emerging areas of technology where universities are leaders, such as biotechnology, than in traditional fields of research. Recent research on the biotechnology industry in the United States suggests that ' . . . commercial success now depends much more on successful and productive collaboration with disparate parties' (Powell and Brantley 1992, p. 382). In the new industrial order where innovation derives from collaborative networks among different organizations, inter-organizational contact and communication is the critical managerial skill. The appointment of individuals from R&D in industry to head university technology transfer units obviously assists such networking, because these individuals bring with them their prior experience and contacts. Networking could be further fostered by encouraging joint management training between industrial R&D personnel and university technology transfer managers. Many American business and engineering schools now offer technical management training programs designed to enhance technology transfer within industry (Badawy 1982). By mixing together university and industrial managers in such programs, collaboration and networking between government agencies, university managers and industrial R&D personnel could be fostered in a non-competitive context. The development and funding of such integrating management programs could also be an appropriate role of government, similar to the role the government of Japan played in fostering quality in Japanese industry by supporting the training of quality engineers (Garvin 1988).

Another important activity could be the development of performance indicators specifically relevant to technology transfer activity in universities. As Feller (1990) has argued, the prior experience and organizational context of university administrators makes them particularly vulnerable to over-investment in potentially lucrative but risky activities. In principle, the problem is not unlike that facing university managers generally, where the 'bottom line' for academic programs and research projects is ambiguous. This problem has been addressed by American universities in part through the development and sharing of various academic performance indicators to provide some guidance for university administrators in planning and budgeting decisions. The American Association of Universities (AAU), for example, composed of America's leading research universities, has developed a systematic 'data exchange' in which data on faculty salaries, student faculty ratios, staffing levels, space, and other critical information are shared among the association members using fictional names to mask the identity of each institution. Given the complexity discussed above of assessing performance in technology transfer activities, it would be extremely useful to have a set of relevant ratios, activity indicators, and critical success factors drawn from the experience of research universities in areas such as patenting and licensing, endowment/investment management, and the management of incubators. These data could provide some context for the investment decisions of universities in technology transfer activities (as a possible starting point, see, for example, the type of data in Table 4). Again, an important role of government in this area might be collaborating with industry to stimulate the development of such a performance indicators project through an appropriate government agency such as NSF or through a professional group such as AAU. As with the suggested effort in management training, a continuing aim of these policies should be to sponsor and support collaboration and ongoing networks among industry, government agencies, and universities.

Finally, much of the literature on university–industry collaboration has been dominated by critics concerned about the possible negative effects of these activities on essential values and functions of academic work. As suggested above, many of these concerns are legitimate. However, the new, entrepreneurial phase of technology transfer activity, and the support it receives from governments both in the United States and abroad, suggests that despite potential risks technology transfer activity will unlikely be curtailed. Rather, the form of university–industry technology transfer is likely to be modified as more is learned. Toward this end both the critics and advocates of technology transfer between universities and industry would be aided by systematic research on the management of the technology transfer process utilizing more complex and valid measures of performance than were possible in the present study. Furthermore, as suggested in the analysis, frameworks and models derived from the rich tradition of R&D

management research in business and industry could be a particularly valuable basis for the necessary empirical work.

Conclusion

This study presented findings of a national survey of university technology transfer units. The incidence of different types of technology transfer mechanisms in the American university system, particularly newer, more entrepreneurial forms, was suggested. In addition, descriptive characteristics of the organization of these units and of the background of those managing them was presented. A number of individual and managerial variables – years of experience, technical orientation, and frequency of managerial communication – were found to be significantly correlated with perceived unit performance. These relationships bear many parallels to correlates of performance discovered in the industrial R&D research literature, and suggest the potential application of that research to the organizational design and management of university technology transfer units.

These results are based upon small samples in a number of cases, and, in the analysis of managerial and organizational correlates, on a single measure of perceived unit performance. Additional research is needed on organizational structure, financing and managerial behavior within types of technology transfer units (e.g., licensing and patenting offices), as well as on those factors reported to be critical to the success of each type of unit.

Acknowledgements

This research was supported in part by a grant from the Forum for College Financing of the National Center for Postsecondary Governance and Finance. I also wish to express my appreciation to Professors Harvey Goldstein and Michael Luger as well as to Mr. Suk-Chan Ko for their assistance with this study. I am also indebted to Professor Philip Altbach and an anonymous reviewer for useful suggestions for revision.

References

Allen, T.J. (1985). *Managing the Flow of Technology*. Cambridge, MA: MIT Press.

Badawy, M.K. (1982). *Developing Managerial Skills in Engineers and Scientists*. New York: Van Nostrand Reinhold.

Baldridge, J.V., Curtis, D.V., Ecker, G.P., and Riley, G.L. (1978). *Policy Making and Effective Leadership*. San Francisco: Jossey-Bass Publishers.

Carnegie Foundation for the Advancement of Teaching (1987). *The Carnegie Classification of Higher Education*. Princeton: Princeton University Press.

Clark, B.R. (1983). *The Higher Education System.* Berkeley: The University of California Press.

Clark, B.R. (1987). *The Academic Life: Small Worlds, Different Worlds.* Princeton: Carnegie Foundation for the Advancement of Teaching.

DeMeyer, A. (1985). 'The flow of technological innovation in an R&D department', *Research Policy* 14(1), 315–328.

Dertouzos, M.L., Lester, R.K., and Solow, R.M. (1990). *Made in America: Regaining the Productive Edge.* Scranton, Pa: Harper Collins.

Dill, D.D. (1985). 'Theory versus practice in the staffing of R&D laboratories', *R&D Management* 15(3), 227–241.

Dill, D.D. (1990). 'University/industry research collaborations: an analysis of interorganizational relationships', *R&D Management* 20(2), 123–129.

Fairweather, J.S. (1988). *Entrepreneurship and Higher Education: Lessons for Colleges, Universities and Industry.* ASHE-ERIC Higher Education Report No. 6. Washington, D.C.: Association for the Study of Higher Education.

Fairweather, J.S. (1989). 'Academic research and instruction: the industrial connection', *Journal of Higher Education* 60(3), 388–407.

Feller, I. (1990). 'Universities as engines of R&D-based economic growth: they think they can', *Research Policy* 19(4), 335–348.

Garvin, D. (1988). *Managing Quality: The Strategic and Competitive Edge.* New York: Free Press.

Geiger, R.L. (1988). 'Milking the sacred cow: research and the quest for useful knowledge in the American university since 1920', *Science, Technology and Human Values* 13(3–4), 322–348.

Geiger, R.L. (1990). 'Organized research units – their role in the development of university research', *The Journal of Higher Education* 61(1), 1–19.

Geiger, R.L. (1992). 'The ambiguous link: private industry and university research', in Becker, W.E., and Lewis, D.R. (eds.), *The Economics of Higher Education.* Boston: Kluwer, pp. 265–298.

Keller, R.T. (1986). 'Predictors of performance of project groups in R&D organizations', *Academy of Management Journal* 29(4), 715–726.

Larsen, J., and Wigand, R. (1987). 'Industry–university technology transfer in microelectronics', *Policy Studies Review* 6(3), 584–595.

Mayfield, L.G., and Schultzman, E. (1987). 'Status report on the engineering research centers program', *Research Management* 30(1), 35–41.

Peters, L.S., and Fusfeld, H. (1983). 'Current U.S. university/industry research connections', in National Science Board, *University–Industry Research Relationships: Selected Studies.* Washington, D.C.: National Science Foundation.

Peters, L.S., and Wheeler, P.A. (1988). *Technology-Based Regional Economic Development: An Overview.* Troy, NY: Center for Science and Technology Policy, R.P.I.

Powell, W.W., and Brantley, P. (1992). 'Competitive cooperation in biotechnology: learning through networks?', in Nohria, N., and Eccles, R.G. (eds.), *Networks and Organizations: Structure, Form, and Action.* Boston: Harvard Business School, pp. 366–394.

Raelin, J.A. (1986). *The Clash of Cultures: Managers and Professionals.* Boston: Harvard Business School.

Roberts, E. (1989). 'The personality and motivations of technological entrepreneurs', *Journal of Engineering and Technology Management* 6(1), 5–24.

Schein, E. (1978). *Career Dynamics: Matching Individual and Organizational Needs.* Reading, MA: Addison-Wesley.

Smith, T.R., and Drabenstott, M. (1992). 'The role of universities in regional economic development', in Becker, W.E., and Lewis, D.R. (eds.), *The Economics of Higher Education.* Boston: Kluwer, pp. 199–222.

Souder, W.E. (1987). 'The strategic management of technological innovation: a review and a model', *Journal of Management Studies* 24, 25–42.

Stankiewicz, R. (1986). *Academic and Entrepreneurs: Developing University–Industry Relations.* London: Francis Pinter.

Tornatzky, L.G., and Fleisher, M. (1990). *The Process of Technological Innovation.* Lexington, Mass.: Lexington.

Tushman, M.L., and Katz, R. (1980). 'External communication and project performance: an investigation into the role of gatekeepers', *Management Science* 26(11), 1071–1085.
Van de Ven, A. (1986). 'Central problems in the management of innovation', *Management Science* 32(5), 590–607.