Knowledge and Technology Transfer: Levels and Key Factors

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Abstract

Most current literature on knowledge and technology transfer (Appropriability Model, Dissemination Model, and Knowledge Utilization Model), describe the process of transfer in details, but has limitation in terms of their application in contemporary high-tech industries since most studies have not provided plausible explanation on levels and factors affecting transfer of knowledge and/or technology. To overcome these limitations, the four levels of knowledge and technology transfer are suggested: Knowledge and Technology Creation (Level I), Sharing (Level II), Implementation (Level III), and Commercialization (Level IV). Comprehensive literature identifies sixteen variables affecting the process and results of knowledge and technology transfer. The survey results show four key factors in knowledge and technology transfer: Communication, Distance, Equivocality, and Motivation. Communication refers to the degree to which a medium is able to efficiently and accurately conveys task-relevant information and media while distance involves both physical and cultural proximity. Equivocality refers to the degree of concreteness of knowledge and technology to be transferred while motivation involves incentives for and the recognition of the importance of knowledge and technology transfer activities. Further analysis shows that there are four distinctive clusters and they show very contrasting characteristics in terms of four key factors. The careful mapping of the four clusters on the four key factors show very informative knowledge and technology transfer patterns, the Knowledge and Technology Transfer Grid. Finally, actions to increase communication interactivity and motivation, and to reduce cultural distance and equivocality are suggested.

1. Introduction

Knowledge and technology accumulation, transfer, application, and diffusion are key to sustainable economic prosperity in the emerging global economy of the 21st century. Rapid advances in Information Technologies (IT) and declining costs of producing, processing and diffusing knowledge and technologies are transforming social and economic activities worldwide. The knowledge and technology revolution is critically different from the past industrial revolution in that it is based upon a shift of wealth creating assets from physical things to intangible resources based on knowledge and technologies. Thus, effective management and transfer of knowledge and technologies are believed to be the most critical capability of individuals, organizations, and nations in the globalized 21st knowledge society.

Knowledge and technology transfer is a complex, difficult process even when it occurs across different functions within a single product division of a single company (Zaltman et al., 1973; Kidder, 1981; Smith and Alexander, 1988). Moving innovative ideas from the research lab through production, marketing, and sales to the customer in a timely profitable manner has proven to be a difficult challenge even for the best managed U.S. firms (Peters and Waterman, 1982; Leonard-Barton, 1988; Badaway, 1991). The challenges of technology transfer are magnified when crossing organization boundaries (Williams and Gibson, 1990). Most current literature on knowledge and technology transfer describe the process of transfer in details, but has limitation in terms of their application in contemporary high-tech industries since most studies have not provided plausible explanation on levels and factors affecting transfer of knowledge and/or technology.

Thus, the purposes of this paper were: (1) to define knowledge and technology transfer and categorizes the levels of transfer, (2) to identify key factors affecting transfer of knowledge and technology through empirical data, and (3) to develop knowledge and technology transfer grid to provide practical guidelines.

2. Knowledge and Technology Transfer

Theoreticians and practitioners define the concepts of knowledge and technology transfer in many different ways. There is usually agreement, however, that (1) knowledge and technology is not just "thing," and (2) that transfer requires a profoundly human endeavor (Gibson and Smilor, 1991). Transfer is the movement of knowledge and technology via some channel from one individual or organization to another. The transfer of knowledge and technology is a particularly difficult type of communication if that it often requires collaborative activity between two or more individuals or functional units who are separated by structural, cultural, and organizational boundaries. Appreciation for the human component in knowledge and technology transfer directs us away from thinking of simply moving knowledge and technology from point "A" to point “B”. Instead, think of knowledge and technology transfer as an interactive process with a great deal of back-and-forth exchange among individuals over an extended period of time (Gibson and Smilor, 1991).

Three models of technology transfer have been most prevalent (Devine et al., 1987). The “Appropriability Model” emphasizes the importance of the quality of research and competitive market pressures in achieving technology transfer. This model assumes the myth that good technologies sell themselves, but seldom true in real world. The “Dissemination Model” concentrates on the diffusion of innovation (Rogers and Kincaid, 1982). The objective is to disseminate innovations to individual users. But one-way communication from expert to user does not characterize the process. Most current one is “Knowledge Utilization Model”, which emphasizes the importance of (1) interpersonal communication between researchers and users, and (2) organizational barriers and facilitators of transfer. But this model tends to reduce a very complex process to chronologically ordered stages.

To overcome the limitations of above mentioned three models, the following four levels of knowledge and technology transfer are suggested based on Gibson and Smilor's (1991) technology transfer model (refer to Figure 1).

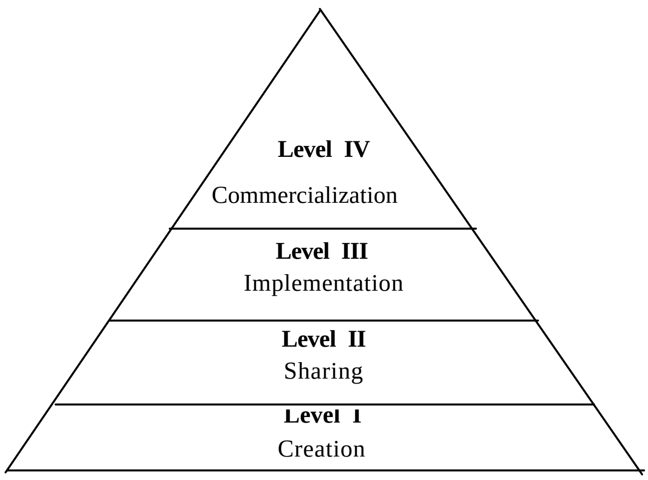

Figure 1: Four Levels of Knowledge and Technology Transfer

At Level I, knowledge and technology creation, individuals conduct state-of-the-art research or develop the best practices into knowledge, and announce these results by such varied means as research publications, videotapes, teleconferences, news, and anecdotes. Knowledge and Technology transfer at this level is a largely passive process that requires little collaborative behavior among the transceivers, although the researchers may work in teams or across organizational or even national boundaries. Level II knowledge and technology transfer, sharing, calls for the beginnings of shared responsibility between knowledge and technology developers and users. Success occurs when knowledge and technology is transferred across personal, functional, or organizational boundaries, and it is accepted and understood by designated users.

In Level III transfer, success is marked by the timely and efficient implementation of knowledge and technology. For Level III success to occur, knowledge and technology users must the resources needed to implement. Knowledge and technology implementation can occur within the user organization in terms of manufacturing or other processes, or it can occur in terms of services or best practices. Level IV transfer, knowledge and technology utilization, centers on commercialization. Level IV builds cumulatively on the successes achieved in attaining the objectives of the three previous stages but market strength is required. Success is measured in terms of return of investment (ROI) or market share.

Research on technology transfer has traditionally concentrated on effective linkage and information movement usually to the exclusion of management theory (Levenson and Moran, 1987). An exception of this tradition is Creighton et al. (1985), who isolated nine elements that were repeatedly stated or implied in descriptions of technology transfer models. They are: organization, project, documentation of information, distribution of information, linking, capacity to transport or receive and to act, credibility of organizations in the transaction, willingness to transmit, receive or implement ideas, and reward. Smilor et al. (1990) emphasize the importance of difference between consortia and their member companies in terms of academic and business values, networking and information sharing, long versus and short-term perspectives, universal versus particular research objectives, and performance evaluation. Other variables such as risk, cost, and timing of the transfer process are also cited as being important to successful transfer (Inman, 1987; Pinkston, 1989; Gibson and Rogers, 1991). From comprehensive literature review, the following 16 research variables are identified as affecting the process and results of knowledge and technology transfer (Creighton et al, 1985; Gibson and Rogers, 1991; Inman, 1987; Levinson and Moran, 1987; Pinkston, 1989; Smilor et al., 1990). They are: person-to-person contacts, knowing whom to contact, variety of communication channels, set up transfer office or committee, a sense of common purpose, understanding of nature of business, attitude and values, increase awareness of transfer, concreteness of knowledge/technology, establish a collaborative research program, clear definition of transfer, programs (Training, Demo, Tutorials), provide incentives for transfer, share success stories, push and pull for technology, and product champion.

3. Research Methodology

MCC (Microelectronics and Computer Technology Corporation) was selected as the subject of this study. MCC – one of the nation's largest, and most complex for profit R&D consortia – began operation in Austin, Texas in 1983. The MCC was organized to pursue long-term research aimed at significant advances in computer and semiconductor technologies. By 1991, the consortium was funded by 22 shareholder companies, 36 associate members and three government sponsors at about $60 million per year. For hundred thirty full-time employees and 60 part-time employees staffed the consortium. The consortium had spent about $350 million of its member company funds, been awarded 56 patents, and been issued more than 50 licenses for its technologies. It is the responsibility of the member companies to turn the MCC-developed technologies into marketable products and processes. Thus MCC provides most natural setting to study knowledge and technology transfer phenomena.

Since the research objective of this study is to identify important factors affecting knowledge and technology transfer, researchers employed a grounded theory approach (Glaser and Strauss, 1967; Argyris, 1972; Alderfer and Smith, 1982; Pfeffer, 1982; Martin and Turner, 1986), and collected multiple forms of data to uncover and explain knowledge and technology transfer. Based on case studies done by Gibson and Smilor (1991), the questionnaire was developed. The survey consists of the total of 61 questions concerning items facilitation, inhibition, effectiveness of methods, and improvement alternatives of knowledge and technology transfer. These 61 questions are to measure 16 variables described in the previous section.

6.2 Data Collection

The survey had a target population of 430 respondents which included MCC scientists and managers, and shareholder representatives, and assignees that resided at MCC as well as MCC's board of directors and research advisory panels which are composed of shareholder personnel that reside at the respective member companies. One hundred forty six respondents completed and returned the survey for a response rate of 34 percent. The response rate is considered to be satisfactory in social science field. And there were no noticeable incidents to suspect the bias in survey responses.

6.3 Reliability and Validity

Reliability refers to the stability of measures over a variety of conditions (Nunally, 1978). The amount of error made by any measure is determined by Cronbach's alpha applied to interitem scores and to overall measures. The results of this reliability test on research variables are shown in Table 1. Brown (1983) recommends the minimum value of 0.80 for tests measuring attitudes or values. Nunally (1978) argues that the satisfactory level of exploratory study is 0.7 or above. Cronbach's alphas are in the last column of Table 1 and all variables meet Nunally's standard and come close to Brown's recommendation. Therefore, the reliability of measures is concluded satisfactory.

Table 1: Descriptive Statistics of Research Variables

Variable Description	Mean	St.d	Cronbach's Alpha
Person-to-person contacts	5.66	0.80	0.7234
Concreteness of technology	5.57	0.73	0.8081
Understanding of nature of business	5.29	1.00	0.7456
Push and pull for technology	5.31	0.87	0.7146
A sense of common purpose	4.86	0.98	0.8823
Knowing whom to contact	4.68	1.23	0.8421
Provide incentives for transfer	4.56	1.41	0.7576
Programs (Training, Demo, Tutorials)	4.55	1.25	0.7891
Clear definition of transfer	5.05	1.06	0.8081
Increase awareness of transfer	5.01	1.13	0.8342
Variety of communication channels	4.50	1.09	0.7871
Share success stories	4.33	1.29	0.7265
Attitude and values	4.16	1.42	0.7177
Set up transfer office or committee	3.92	1.38	0.8277
Product champion	3.13	1.39	0.8331
Establish collaborative research programs	2.38	1.34	0.7863

N = 146

4. Key Factors in Knowledge and Technology Transfer

To categorize 16 research variables into a small number of key factors, the factor analysis was performed. The factor analysis on survey data suggests the following four key factors in knowledge and technology transfer (refer to Table 2). One variable (Set up transfer office or committee) had low loading and was excluded from future analyses. The four factors were named as Communication, Distance, Equivocality, and Motivation.

4.1 Communication

Communication refers to the degree to which a medium is able to efficiently and accurately conveys task-relevant information (Daft and Lengel, 1984; Huber and Daft, 1987) and media richness (Daft and Lengel, 1986). Passive communications are media-based and have the capacity to target many receptors while interactive communications encourage interpersonal communication in terms of fast, focused feedback, better chance of transfer (Gibson and Smilor, 1991). Passive links are media-based and have the capacity to target many receptors at low cost, but the sender is often unaware of whether and how the receptors receive and utilize the transferred knowledge and/or technology. Thus such passive linkages are representative of Level I mode of knowledge and technology transfer (refer to Figure 1). Interactive transfer links are defined as being person-to-person media-rich interactions. This mode of transfer relates to Levels III and IV involvement between developers and users.

Table 2: Results of Factor Analysis on Research Variables

Research Variables	Factor 1 Communication	Factor 2 Distance	Factor 3 Equivocality	Factor 4 Motivation
Person-to-person contacts	**0.3685**	0.0016	0.0488	0.0311
Knowing whom to contact	**0.6056**	0.0218	0.1156	0.1051
Variety of communication channels	**0.7286**	0.1965	0.2176	0.1257
A sense of common purpose	0.2395	**0.4798**	0.1209	0.1682
Understanding of nature of business	0.0661	**0.5126**	0.0133	0.0670
Attitude and values	0.1040	**0.4137**	0.1460	0.2328
Increase awareness of transfer	0.3657	**0.6781**	0.1004	0.1959
Concreteness of technology	0.0440	0.1655	**0.4049**	0.2364
Establish collaborative research programs	0.1018	0.2740	**0.3708**	0.1037
Clear definition of transfer	0.0394	0.0326	**0.5925**	0.0316
Programs (Training, Demo, Tutorials)	0.0469	0.0859	**0.6365**	0.1328
Provide incentives for transfer	0.2789	0.1012	0.0824	**0.3578**
Share success stories	0.0682	0.2306	0.2957	**0.5024**
Push and pull for technology	0.2713	0.0484	0.1448	**0.6106**
Product champion	0.1887	0.1508	0.1218	**0.5113**
Set up transfer office or committee	0.2004	0.0191	0.2797	0.1358
Eigenvalue	1.4874	1.3751	1.3510	1.2730

4.2 Distance

Distance involves both physical and cultural proximity (Rogers and Kincaid, 1982; Hatch, 1987). With explosive development of IT, cultural differences loom as the more important dimension of distance than geographical separation (Albrecht and Ropp, 1984; Pinkston, 1989). The present research suggests that cultural similarity/dissimilarity is an important predictor of whether boundary spanning communication will be facilitated or discouraged. The more developers and users understand the values, attitudes, and ways of doing things each other, the greater the chance of successful transfer of knowledge and technology. This distance factor becomes critical as we move up in knowledge and technology transfer modes (from Level I to Level IV).

4.3 Equivocality

Equivocality refers to the degree of concreteness of knowledge and technology to be transferred (Weick, 1990; Pinkston, 1989; Avery, 1989). Highly equivocal knowledge and technology is harder to understand, more difficult to demonstrate, and more ambiguous in its potential applications (Gibson and Smilor, 1991). While such ambiguity may facilitate different users perceiving the same technology as suitable for unique needs, such ambiguity is not send to facilitate knowledge and technology transfer from a Level III perspective, i.e., applying the knowledge and technology efficiently and in a timely manner.

4.4 Motivation

Motivation involves incentives for and the recognition of the importance of knowledge and technology transfer activities. Personal motivation for actively participating in and supporting knowledge and technology transfer processes, as a developer or a user, can range from positive to hostile. Also personal motivation for knowledge and technology transfer varies by factors such as the importance of transfer activities to the individuals involved to whether the organization's culture rewards those who engage in transfer activity (Badaway, 1988; Dornbush and Scott, 1975). Again, this motivation factor becomes critical as we move up in knowledge and technology transfer modes (from Level I to Level IV).

5. Knowledge and Technology Transfer Grid

To test whether there are noticeable patterns in terms of 4 key factors, cluster analysis was performed on 146 responses. The results are summarized in Table 3. Surprisingly, there are only four distinctive clusters detected and they show very contrasting characteristics in terms of four key factors. Quite interestingly, for each key factor two clusters show high scores and two clusters show low scores. This phenomenon makes very noticeable observation.

Table 3: The Results of Cluster Analysis

Cluster	N	Communication	Equivocality	Distance	Motivation
I	38	5.47 H	4.92 L	5.07 L	4.88 H
II	45	5.19 H	3.78 H	4.60 H	4.42 H
III	32	4.64 L	4.63 L	4.95 L	4.15 L
IV	31	4.26 L	4.37 H	4.75 H	3.72 L
Total	Average St.d.	4.95 0.64	4.39 0.59	4.83 0.57	4.33 0.63

* Equivocality and Distance measures: H and L are reversed since how scores actually mean low, i.e., the lower the score is in distance, the farther the distance is.

Four key factors with high and low scores each could come up with the total 16 combinations ($2^4 = 16$), but in our research only four clusters were identified. This suggests that there seems to exist some patterns in knowledge and technology transfer in terms of communication, distance, equivocality, and motivation. The careful mapping of the four clusters on the four key factors show very informative knowledge and technology transfer patterns. The Knowledge and Technology

Transfer Grid, as shown in Figure 2, depicts four combinations of four key factors of communication, distance, equivocality, and motivation.

In Cell I all elements are right for the successful application of the transferred knowledge and/or technology. Because of highly interactive communication processes, a variety of incentives and recognitions for knowledge and technology transfer, cultural proximity among developers and users, and because the knowledge and/or technology is unambiguous and its application understood, successful knowledge and technology transfer, in terms of Levels III and IV involvement, is more likely to occur.

Successful knowledge and technology transfer in Cell IV is least likely when there is low interactive communication, low personal motivation, high cultural distance, and high equivocality. In this situation, knowledge and technology transfer is not likely to occur because transmitters and receivers do not interact with one another, because there are neither incentives nor recognitions for those involved in the transfer process, because there are wide cultural distances, and because the knowledge and/or technology is ambiguous and the applications uncertain. The knowledge and/or technology may be developed, but it is neither accepted nor commercialized in terms of Levels III or IV involvement.

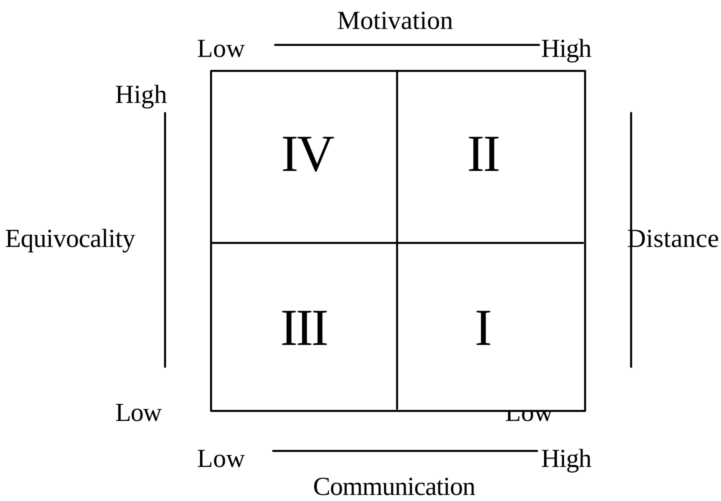

Figure 2: Knowledge and Technology Transfer Grid

In two other situations depicted in the Knowledge and Technology Transfer Grid (Cells II and III), there are a variety of combinations of factors in each situation, each is initially characterized by two positive and two negative factors in relation to successful knowledge and technology transfer and commercialization. Cell II describes the situation in which there is high interactive communication and high motivation combined with high equivocality and high cultural distance. In other words, while there may be interactive communication processes in conjunction with high personal motivation for knowledge and technology transfer, the knowledge and/or technology is ambiguous and uncertain in its applications and there exists cultural barriers between transmitters and users.

Cell III is the exact opposite situation of Cell II. There is low cultural distance and low equivocality combined with low interactive communication and low personal motivation. In other words, while there may be cultural closeness as well as unambiguous knowledge and/or technology, communication tends to be passive and people are not motivated to actively participate in transfer process. In this situation, the problem exists in the management since technical and cultural environment is favorable for knowledge and technology transfer. The management should devise mechanisms to enhance interactive communication and to provide rewards, recognitions, and incentives to reinforce motivation for knowledge and technology transfer.

6. Managerial Implications

Management can take actions to develop an infrastructure that is supportive of and conductive to Level III and Level IV knowledge and technology transfer. The following suggested actions increase communication interactivity and motivation, and reduce cultural distance and equivocality.

6.1 Communication

Recommendations to improve the effectiveness of communication in knowledge and technology transfer are designed to increase the number and the range of active mechanisms and to disseminate more broadly and effectively passive mechanisms of communications. They are: (1) clearly identify and give authority to persons and or groups to monitor, receive, and appropriately disseminate new technologies; (2) to emphasize the importance of knowledge and technology transfer activities and to increase awareness of successful cases of knowledge and technology transfer; (3) to use visible and highly regarded liaisons to champion during the transfer; and (4) to emphasize the use of highly interactive communication links in the transfer process.

6.2 Distance

To decrease the cultural distance between researchers and users, knowledge and technology developing and receptor organizations are encouraged: (1) to expand the number and diversity of people interacting in the transfer process to increase mutual understanding of values, attitudes and ways of doing things; (2) to involve a broad range of personnel in the transfer process; (3) to hold knowledge and technology transfer seminars to bring together researchers and users; (4) to encourage and fund on-site visits to research and receptor organizations; and (5) to conduct workshops to provide personnel with a better understanding of the culture and product strategy of transmitters and receptors.

6.3 Equivocality

Recommendations on the equivocality dimensions are designed to make knowledge and technology more understandable and less ambiguous. Knowledge and technology developing and user organizations are encouraged: (1) to clarify expectations for research activities and usability criteria so that research and product development personnel have a better understanding of what each participant expects to get from involvement with the transfer process; (2) to encourage collaborative projects in order to facilitate sharing of research results; (3) to require research programs to have knowledge and technology transfer objectives; (4) to develop education/training programs on selling ideas early in research process; and (5) to encourage on-site demonstrations to make the knowledge and technology more understandable to potential users.

6.4 Motivation

Recommendations to heighten personal motivation focus on providing incentives, rewards and recognition for those involved in transferring knowledge and technology, both in researcher and user organizations. Recognition may include monetary compensations such as bonuses and pay raises, special licensing/royalty arrangements for transferred knowledge and technology, and honoraria for particularly noteworthy achievements in transfer. Recognition may also include featuring individuals and groups in newsletter, in the documentation of success stories, and in videotapes describing knowledge and technology transfer activities.

7. Summary and Conclusions

The purposes of this paper were: (1) to define knowledge and technology transfer and categorizes the levels of transfer, (2) to identify key factors affecting transfer of knowledge and technology through empirical data, and (3) to develop knowledge and technology transfer grid to provide practical guidelines.

Most current literature on knowledge and technology transfer (Appropriability Model, Dissemination Model, and Knowledge Utilization Model), describe the process of transfer in details, but has limitation in terms of their application in contemporary high-tech industries since most studies have not provided plausible explanation on levels and factors affecting transfer of knowledge and/or technology. To overcome these limitations, the four levels of knowledge and technology transfer are suggested: Knowledge and Technology Creation (Level I), Sharing (Level II), Implementation (Level III), and Commercialization (Level IV). Comprehensive literature identified sixteen variables affecting the process and results of knowledge and technology transfer.

MCC (Microelectronics and Computer Technology Corporation) was selected as the subject of this study. One hundred forty six respondents completed and returned the survey for a response rate of 34 percent. The factor analysis on survey data suggests the following four key factors in knowledge and technology transfer: Communication, Distance, Equivocality, and Motivation. Communication refers to the degree to which a medium is able to efficiently and accurately conveys task-relevant information and media while distance involves both physical and cultural proximity. Equivocality refers to the degree of concreteness of knowledge and technology to be transferred while motivation involves incentives for and the recognition of the importance of knowledge and technology transfer activities.

To test whether there are noticeable patterns in terms of 4 key factors, cluster analysis was performed. The results show that there are only four distinctive clusters and they show very contrasting characteristics in terms of four key factors. The careful mapping of the four clusters on the four key factors show very informative knowledge and technology transfer patterns, the Knowledge and Technology Transfer Grid. Finally, actions to increase communication interactivity and motivation, and to reduce cultural distance and equivocality are suggested.

This research has several limitations. First, research setting is much limited. Restriction to MCC does lose the ground for generalization of this study. Also the sample size (N=78) is not large enough to carefully examine all variables and their relationships. Second, there were no dependent variables. While this study identifies key factors affecting knowledge and technology transfer and transfer patterns, the measures that evaluate performance of transfer were not employed. This is because dependent variables such as performance are not easy to measure. Thus the critical associations between key factors and success were not investigated.

There are several directions in which this research can be extended. One suggestion for future effort is to replicate this research with a larger population setting including variety of organizations. The second future research direction is to comprehensively examine whether Knowledge and Technology Transfer Grid is applicable. The third direction concerns the dependent variable. Reliable and valid knowledge and technology transfer performance measures should be devised and empirical tested.

REFERENCES

Albrecht, T. L. and V. A. Ropp, “Communication about Innovation in Networks of Three U.S. Organizations,” *Journal of Communication*, Summer 1984, pp. 79-91.

Alexander, C. P. and K. K. Smith, “Studying Intergroup Relations Embedded in Organizations,” *Administrative Science Quarterly*, Vol. 27, 1982, pp. 365-380.

Argyris, C., *Applicability of Organizational Psychology*, Cambridge Univ. Press, London, 1972.

Avery, C., "Organizational Communication in Technology Transfer between an R&D Consortium and its Shareholders: The Case of the MCC, *Doctoral Dissertation*, The University of Texas at Austin, 1989.

Badaway, M. K., "Managing Human Resources," *Res. of Technology Management*, September-October 1988, pp. 19-35.

Brown, Frederick G., *Principles of Educational and Psychological Testing*, New York: Holt, Rinehart and Winston, 1983.

Creighton, J. W., J. A. Jolly and T. A. Buckles, "The Manager's Role in Technology Transfer," *Journal of Technology*, Vol. 10, No. 1, 1985, pp. 65-81.

Daft, R. L. and R. H. Lengel, "Information Richness: A New Approach to Manager Information Processing and Organizing Design," in B. Staw and L. Cummings (Eds.), *Research in Organizational Behavior*, Vol. 5, JAI Press, 1984, pp. 191-233.

Daft, R. L. and R. H. Lengel, "Organizational Information Requirements, Media Richness and Structural Design," Management Science, Vol. 32, No. 5, 1986, pp. 554-571.

Devine, M. D., T. E. James, Jr., and I. T. Adams, “Government Supported Industry Research Centers: Issues for Successful Technology Transfer,” *Journal of Technology Transfer*, Vol. 12, No. 1, 1987, pp. 27-38.

Dornbush, S. M. and W. R. Scott, *Evaluation and the Exercise of Authority*, Jossey-Bass, 1975.

Gibson, David, V. George Kozmetsky, and Raymond W. Smilor, eds., *The Technopolis Phenomenon: Smart Cities, Fast Systems, and Global Networks*. Savage, Rowman & Littlefield, 1992.

Gibson, David V. and Everett M. Rogers, *R & D Collaboration on Trial: The Microelectronics and Computer Technology Corporation*, Harvard Business Press, 1994.

Gibson, David and Niwa, K., "Knowledge- Based Technology Transfer," *Proceedings of Portland International Conference on Management of Engineering and Technology*, 1991.

Gibson, David and Smilor, Raymond, "Key Variables in Technology Transfer: A Field-Study Based Empirical Analysis," *Journal of Engineering and Technology Management*, Vol.8, 1991, pp. 287-312.

Glaser, B. G. and A. L. Strauss, *The Discovery of Grounded Theory*, New York: Aldine, 1967.

Hatcher, M., “Physical Barriers, Task Characteristics, and Interactions Activity in Research and Development Firms,” *Administrative Science Quarterly*, Vol. 32, 1987, pp. 387-399.

Huber, G. P. and R. L. Daft, “Information Environments,: in F. Jablin, L. Putnam, K. Roberts, and L. Porters (Eds.), *Handbook of Organizational Communication*, Sage: Beverley Hills, CA, 1987.

Inman, Bobby R.(1984), "The Microelectronics and Computer Technology Corporation," in Robert Lawrence Kuhn(1984), *Commercializing Defense-Related Technology*, New York, Praeger, PP. 149-152.

Kidder, T., *The Soul of a New Machine*, MA: Little Brown, 1981.

Leonard-Barton, D., “Implementation as Mutual Adaptation of Technology and Organization,” *Research Policy*, Vol. 17, 1988., pp. 251-267.

Levinson, N. S. and D. Moran, "R&D Management and Organizational Coupling," *IEEE Transactions on Engineering Management*, Vol. 34, No. 1, 1987, pp. 28-35.
Martin, P. Y., and B. A. Turner, "Grounded Theory and Organizational Research," *Journal of Applied Science*, Vol. 22, 1986, pp. 141-157.
Nunally, Jum C., *Psychometric Theory*, New York: McGraw-Hill, 1978.
Peters, T. and R. Waterman, *In Search of Excellence: Lessons from America's Best-Run Corporations*, New York: Harper and Row, 1982.
Pfeffer, J., *Organizations and Organization Theory*, MA: Pitman, 1982.
Pinkston, J. T., "Technology Transfer: Issues for Consortia,: In K. D. Walters (Ed.), *Entrepreneurial Management: New Technology and New Market Development*, Ballinger: Boston, MA, 1989, pp. 143-149.
Rogers, E. M. and D. L. Kincaid, *Communication Networks: A New Paradigm for Research*, New York: The Free Press, 1982.
Smilor, Raymond W., David V. Gibson, and George Kozmetsky (eds.), *Creating the Technopolis: Linking Technology Commercialization and Economic Development*, Cambridge, MA: Ballinger, 1988.
Smith, D. K. and R. C. Alexander, *Fumbling the Future: How Xerox Invented, the Ignored, the First Personal Computer*, New York: William Morrow, 1988.
Weick, K., "Technology as Equivoque: Sense-Making in New Technologies," In P. S. Goodman and L. S. Sproull (Eds.), *Technology and Organizations*, Jossey-Bass: San Fransisco, CA., 1990, pp. 1-44.
Williams, F. and D. Gibson, *Technology Transfer: A Communication Perspective*, Beverly Hills, CA: Sage, 1990.
Zaltman, G., R. Dundan, and J. Holbeck, *Innovation and Organizations*, New York: Wiley, 1973.