

Duality in Technology Transfer Networks: Case of the Federal Government and the Private Sector

George Tesar

Department of Business Administration
Umeå University
SE-901 87 Umea
Sweden
george.tesar@fek.umu.se

Hamid Moini

Department of Finance and Law
University of Wisconsin-Whitewater

Abstract

This paper is formulated to achieve two specific goals. First, to develop a sound understanding of the networks that have evolved in the United States to facilitate the transfer of new technology into commercial markets. Second, to illustrate the formal and informal relationships that exist within these networks. Findings indicate that the focal relationships within the networks are clear; however, it appears that the networks are driven by informal relationships. An examination of the secondary focal relationships indicates that perhaps the networks are driven by intermediary actors who facilitate the flow of new technology in a more informal and perhaps passive way rather than by a formal technology transfer mechanism. Indeed, the focal relationship between governmental agencies and commercial entities presents an interesting set of situations that might potentially hinder technology transfer in many major countries. It is also apparent that the informal relationships imbedded in the technology transfer networks may be as instrumental in commercializing new technology as the formal relations, if not more.

Keywords: Networks, Technology transfer, Government sector, Private sector, Actors

Introduction

The objective of this paper is to examine two networks, their components, and the linkages between them concerned with technology transfer. The two networks, public and private, are instrumental in technology transfer processes in the United States. The presentation has two fundamental aims. The first is to develop an understanding of how new technology developed by governmental agencies is transferred into commercial markets and the second is to examine the formal and informal linkages between them. Although this is a singular case, and the analysis applies only to the technology transfer climate in the United States, some of the new technology is transferred abroad.

Rapid development of new technology has generated a need for systematic review and understanding of how such new technology enters the marketplace. Many governments invest heavily in new technology, but they seldom introduce mechanisms necessary to transfer new technology into the private sector. The Technology Transfer Commercialization Act of 2000 in the United States is an attempt to hold governmental agencies involved in the development of new technology accountable for its commercialization. The Technology Transfer Commercialization Act of 2000 offers a unique opportunity to examine the entire technology transfer network from a theoretical perspective.

In the United States the technology commercialization process begins with the Office of Management and Budget which funds governmental laboratories that are responsible for the development of inventions. Many of these inventions inevitably lead to new technology which is typically commercialized by the private sector in the form of consumer products or services. The technology commercialization process consists of two unique networks that are linked together by a technology transfer process which provides linkage between the public (government) sector and the private (commercial) sector. This duality in the technology transfer process is transparent but contains a specific network culture subject to limited access and difficult exit. The culture is especially important in understanding the informal relationships between the networks.

The analysis presented in this case study has several direct implications for three different sets of actors. Governmental policy makers need to understand the necessary linkages and connections within the networks in order to allocate appropriate future research budgets for the individual research agencies within the government. Furthermore, they need to be aware of the network dynamics between the public and the private sectors. One important aspect underscoring funding decisions is the informal relationships that exist between corporate owned and operated research laboratories and contractor operated research laboratories that, in some cases, might be managed by the top management team of a commercial entity such as a pharmaceutical firm or an aircraft builder. Government policy makers need to understand the implicit and explicit relationships as they relate to direct acquisition and commercialization of new technology by the commercial entities under contract to manage some of the government owned research agencies.

The researchers and scientists working within government laboratories must also have an understanding of how these networks function. Since they may be in frequent contact with researchers and scientists from the private sector, particularly in the context of scientific meetings, conferences, and research publications, they need to be aware of the limits of their networks. They must be aware of information flow within the networks and the impact of information flow outside of the networks, specifically because the federal government generates revenue from the licensing of inventions and patents developed in the government owned research laboratories.

Finally, managers responsible for the technology acquisition and commercialization efforts of commercial entities also need to be familiar with the dynamics of the two networks. From a competitive perspective they may want to supplement their own sources of new technology with additional technology available in the public sector. They must understand the linkage between the two networks. They must be aware of the transformation process that an invention must follow to become a commercially viable market offering.

Underscoring the two networks is an implicit assumption that diffusion of innovation from the public sector to the private sector and eventually into the market is the real justification for government research. Consequently, government policy makers, researchers and scientists, and corporate managers need to be aware of how these networks operate and how they can best serve the

commercial entities. Yet, virtually no empirical research has been done describing these networks or assessing the importance of these networks to the day-to-day commercialization of technology from public sources. At the same time, only a marginal understanding has been generated of how the two networks operate over a longer period of time. Additional research is needed to explore these complex issues. This case depicting the technology transfer process and commercialization of new technology in the United States is only one example. Additional examples need to be developed to represent other major countries concerned with these same issues.

Literature

The literature review in this area clearly indicates that the theoretical aspects of networks has direct application to assessment of the technology transfer process between the public and the private sectors; few, if any, published empirical studies have attempted to apply the networks' theoretical framework to this case.¹ Available literature in both commercialization of technology and in business network theory suggest that the concept of the two networks proposed in this presentation, the public and the private sector networks, have not been researched from the perspective of business network theory. After an extensive literature survey it can be concluded that there is a research gap between researchers interested in commercialization of technology by governmental agencies and researchers focusing on managerial issues concerned with corporate technology diffusion. Additional studies are needed to close this gap.

Technology and its management is a well-discussed and age-old issue in any culture. Different cultures and ways of doing business have shaped their unique technological identity. This unique technological identity frequently carries considerable market currency, for example, Swiss watches, Italian racing cars, or French cheese. In many countries there is a close link between the government and commercial entities that diffuse technology into the commercial markets. Governments and governmental agencies have stimulated and managed technology (Snow 1961). In Japan, the Ministry of International Trade and Industry (MITI) had considerable control over several industries with particular technological specializations such as electronics and automobile production (Cusumano 1989). Most governments are interested in diffusing new technology into the private sector. They believe that new technology can be commercialized more effectively and efficiently if it is done by private entities. In order to diffuse technology governments and governmental agencies need to cooperate with the private sector and this cooperation inevitably leads to potential conflicts of interests and in some cases even unfair competition. This process often requires close monitoring by society and relevant interest groups (Drucker 1981).

Historical perspectives also suggest that attempts to diffuse new technology, particularly technology that was developed in government financed laboratories, is a complex process that involves government agencies, private corporations, and even university operated research laboratories. For example, from the late 1960s, throughout the 1970s, and well into the 1980s, the United States government developed several programs and procedures to diffuse a variety of technological initiatives through a number of governmental agencies (Hough 1975). Although many of these efforts were under funded, and frequently not accepted by commercial markets, many of the mechanisms for future attempts to commercialize new technology, such as public sector demonstration projects, still remain in the chronicles of governmental agencies. Many of the programs and procedures are still in place today but are being used in a different context. For example, the public demonstration projects that were used in the 1970s to commercialize electric and hybrid vehicles today are used to commercialize wind generated electric power or garbage collection and recycling programs (Tesar and Cavusgil 1978).

The development of commercialization programs for new technology requires a close working relationship between the public and private sectors. As confirmed by a number of such initiatives in the past, this requires building a close network between governmental agencies, their laboratories, and private entities. The public sector, represented by governmental agencies, is good in formulating and administering these initiatives, but lacks experience in implementing and evaluating them. Public administrators, politicians, and academics have attempted to introduce viable solutions to the problems of implementing new technology with minimal success. After many attempts, the approach

¹ The information used in the preparation of this case study was obtained from a variety of sources including government reports and publications, consulting testimonials, and annual financial reports.

developed by House and Jones (no date) was accepted by public sector administrators as a viable approach to diffusion of technology.²

One stream of literature, mostly nonacademic, suggests that many governmental agencies were not comfortable with their inability to successfully diffuse and commercialize new technology and needed assistance from the private sector. Agencies such as the Department of Energy, Department of Agriculture, and even the Department of Treasury (responsible for printing of currency notes and minting coins) attempted to use marketing to commercialize their new technology initiatives in the public sector.³ Eventually, they forged alliances and built networks with private companies to bring new technology to the market (Tesar 1981). This part of the literature suggests that governmental agencies need to cooperate with the private sector in order to commercialize new technology. At the same time, this cooperation produces a series of networks and network components that may not necessarily be efficient and effective as far as the financial expenditures are concerned (Sturdivant 1981).

Another stream of literature, mostly professional, also suggests that several attempts have been made to improve and closely monitor the apparent networks between governmental agencies and the private sector, including universities (Mavin 1999). One attempt is to educate the scientists and engineers working in governmental agencies about business decision-making and, at the same time, provide business managers with an understanding of the public sector. Educational programs have been designed to assist government technicians in developing a better understanding of functions such as marketing, finance, and management. Business managers are briefed by various officials of governmental agencies about their concerns regarding technology transfer and diffusion practices (Tesar and others 2003).

The formation of networks among the actors in both the governmental and private sectors is becoming a major concern among government administrators worldwide. In some instances, as presented in the public press, small business managers are concerned that they are too small to join these networks and, therefore, cannot benefit from them as much as the large firms. These are significant research issues that need to be considered from several perspectives, including the network perspective. A review of the literature presents virtually no meaningful studies concerned with these issues; the literature does, however, suggest that no efforts have been made to systematically describe the overall network formed by governmental agencies and the private sector companies or networks that provide the platform for transfer of technology into the marketplace.

Although no formal studies can be found that directly suggest the application of business network theory to these types of networks, it is conceptually feasible to suggest its potential applicability in these types of networks. That is, networks formed between governmental agencies and private companies can be described and studied in the context of business network theory. The implicit duality of this approach parallels many previous studies, including the seminal study presented by Andersen, Håkansson and Johanson (1994). Strategic implications of similar networks and strategic management thinking associated with them have also been discussed (Gadde, Huemer, and Hakansson 2003). Other business network theory researchers suggest similar parallels between these types of networks and the conventional business networks (Håkansson and Snehota 1989).

The key issue contained in business network theory, in addition to the concepts of duality, strategic managerial thinking, and the necessity of network formation and membership by commercial entities, is the concept of trust. Fukuyama (1995) is credited with in-depth development of the concept of trust in general, although he also examined its implications for business networks. Additional significant contribution of trust to business network theory was further presented by Huemer (1998) in his doctoral dissertation. The concept of trust is particularly relevant in this presentation because of the interaction of two distinctly different cultures (the public and private sector cultures).

² *Getting It Of the Shelf: A Methodology for Implementing Federal Research* by P.W. House and D.W. Jones is not dated but it was published in the 1970s and for several years was considered to be the handbook on implementation of public demonstration projects among technology specialist in the U.S. government.

³ According to several authors this notion gave a raise to the concept of *social marketing*, see P.N. Bloom and W.D. Novelli "Problems Applying Conventional Wisdom to Social Marketing Programs," in Mokwa and Permut (1981).

In summary, this presentation is based on several sources of information and a review of available literature. Technology diffusion literature from sources within the U.S. government is relatively old but well established. Many governmental agencies actively participated in technology diffusion in the 1970s and 1980s and published voluminous literature on the subject. In the 1980s there was a major effort to develop substantial literature in the field of governmental marketing of consumer related products and services such as hybrid automobiles, wind generated energy, or even pharmaceutical products. The notion of assisting governmental agencies with commercialization of new technology into the marketplace was also well documented by the publication of both theoretical and applied literature. Much of this literature is dated by today's research standards. Nevertheless, this literature suggests that no efforts have been made to systematically describe the overall network, or networks, that provide the platform for transfer of technology into the marketplace.

Networks

The entire technology transfer process is presented in Diagram 1. The process consists of two networks: (1) the public network and (2) the private network. The focal relationship in the two networks is the linkage between the centerpieces of each network: governmental agencies in the public sector network and the commercial entities in the private sector network. The secondary focal relationships represent linkages between (1) governmental agencies and university operated research laboratories and (2) between commercial entities and university operated research laboratories. The primary focal relationship provides the principal connection for transfer of substantive technology and know-how. The secondary focal relationships provide more informal technology transfer options along with many intangibles closely associated with technology transfer.

Public Network

The public sector technology transfer network begins with the United States government appropriating funds for technology development projects. In some instances the appropriations target specific initiatives while in other appropriations the initiatives may be unspecified or futuristic in nature. The Office of Management and Budget (OMB) is informed of each appropriation and sends the information to the agency responsible for the project under each appropriation. At the same time, the Technology Transfer Commercialization Act of 2000 (TTCA) is set in motion to assure that each governmental agency, in each appropriation, considers the potential impact of each appropriation in the context of TTCA. This means that each agency needs to track how each new government funded project will comply with the TTCA initiative.

Another actor directly involved in this process is the Department of Commerce (DOC) which is responsible for reporting on all technology initiatives undertaken by all governmental agencies. The DOC acts as an information depository and reporting mechanism for the government. DOC generates reports and up-dates on technological developments and their commercialization.

In order to implement each new technology development and commercialization project the responsible governmental agency has several options. The agency has the potential to undertake the development within its own research laboratory; virtually every governmental agency has several research laboratories exclusively under its administration. Or, it can contract the development to a contractor operated research laboratory. As illustrated in Diagram 1, the contractor operated laboratory may be operated by one of three actors from outside of the public sector: (1) an independent commercial research laboratory (privately owned and independent research facility), (2) a corporate owned and operated research laboratory (laboratory owned by a major commercial entity), or (3) a university operated research laboratory (laboratory owned by a research university).

Each governmental agency decides in which type of laboratory the new technology will be developed. Regardless whether the development takes place in a government owned laboratory or in a contractor operated laboratory, the responsible governmental agency drafts a contractual statement of objectives including plans for commercialization of the new technology. The outside actors' relationships are defined under a contract for the duration of the project.

The additional actor in the public network is the agency's technology transfer unit directly responsible for technology transfer into the private sector. Each governmental agency operates such a unit which

is typically staffed with scientifically trained administrators. Agency technology transfer units serve as the mechanism for physical transfer of new technology into the private sector.

Within the public network there are two linkages relevant to the technology transfer and commercialization efforts: (1) the focal relationships between the governmental agencies and the commercial entities in the private network—the official administrative and managerial connection, and (2) the linkage between the agency's technology transfer unit in the public network and the commercial entity's technology transfer and acquisition unit in the private network—the path for technical implementation aspects of technology transfer and commercialization issues.

Private Network

The private technology transfer network is clustered around the commercial entities that have a focal relationship with governmental agencies in the first part of the network. Commercial entities typically operate their own technology transfer and acquisition units. At the same time, most commercial entities also manage corporate owned and operated research laboratories. Primarily for new technology assessment reasons, there is frequently an exchange of information between the technology transfer and acquisition units and the corporate owned and operated research laboratories. Some corporate entities include in their network independent commercial research laboratories that also work with contractor operated research laboratories providing research for governmental agencies in the public sector.

Other important components of the private sector network are the commercialization of technology units, or corporate marketing units, owned by the commercial entities. These units are responsible for commercialization efforts of individual commercial entities and are typically a part of the corporate marketing strategies. The commercialization of technology in the marketplace is typically carried out by marketing operations.

University research and university operated research laboratories also play an important part of this network. University operated research laboratories maintain open relationships with both governmental agencies and commercial entities and will be examined later.

Network Constructs

A number of constructs need to be considered within this network—constructs that are important in understanding the aspect of network duality in technology transfer. These include the environmental conditions inherent within the network, competitiveness, cooperation, individual relationships, trust, and output of the network.

There are two sets of environmental conditions that exist side by side within the two networks. The public sector network is representative of a not-for-profit environment focusing on social good while the private sector network is very much profit focused. The two environments create different sets of goals and objectives between the government administrators and business managers involved in technology transfer processes.

Competitiveness in the private sector network is very strong among commercial entities in several areas including: (1) access to new technology through the agencies' technology transfer units, (2) bidding on contracts to operate research laboratories serving governmental agencies, and (3) having research laboratories owned by commercial entities operate research laboratories for governmental agencies. The combination of these competitive relationships eventually has an impact on a commercial entity's ability to successfully introduce a commercial innovation in the marketplace.

Informal cooperative arrangements are common between several actors within each network. Commercial entities cooperate with the independent commercial research laboratories as their clients and receive informal feedback from them regarding activities within the public sector. At the same time, many commercial entities have strong ties to university operated laboratories through contractual arrangements and informal benefactoral sponsorships.

There are both formal and informal relationships in these networks. Formal relationships are validated by contracts while informal relationships are accomplished through personal contacts

among scientists, administrators, and business managers. A great deal of information is communicated via informal relationships.

One major construct in these networks is trust. There are three groups of actors that practice a high level of trust within each group. The scientists in the technology transfer and commercialization sector are bound by one element of trust. The nature of this trust is scientific and it relates to the preservation of scientific values. The second element of trust is among the government administrators and the third is among the business managers managing the commercial entities. Surprisingly, there appears to be a low level of trust between the administrators in the public sector networks and the business managers in the private sector networks.

The tangible output produced by the actors in the networks appears to be robust and viable from both the government and business points of view. The private sector network derives substantial benefits from commercializing technology developed in the public sector network.

An overall assessment of the combination of these constructs suggests that the focal relationship between governmental agencies and private entities is socially productive and profitable. Although the public sector network is administered, or managed, differently than the private sector network, the networks' constructs function in a positive direction.

Networks' Components

There are two major components of the technology transfer networks that cross both network boundaries. Each needs to be considered separately. Both components are presented in Diagram 2. The first component describes the relationships between university research, university operated laboratories, commercial entities, and contractor operated research laboratories. This component is important for two reasons. In a technology transfer situation there is a very close relationship between research conducted in university operated research laboratories and commercial entities. This is because many commercial entities contract with university operated research laboratories and, in some cases, support their research. Since a number of university operated research laboratories also operate research laboratories under contract, the commercial entities benefit from their government connections. These relationships are particularly important in instances where cutting edge technology is being developed and in which commercial entities, through informal relationships inherent in the system, receive early information about potential transfer and commercialization opportunities.

The second component that crosses network boundaries is equally as important. Governmental agencies contract with corporate owned and operated research laboratories to operate their research laboratories. There is an informal link between the corporate scientists and business managers in the corporate owned and operated research laboratories. Simultaneously, there is an informal contact with the administrators responsible for laboratories owned by governmental agencies. Through these relationships a great deal of information gets exchanged within the commercial entity regarding activities in the governmental laboratories. A similar situation exists between independent commercial research laboratories and the research laboratories that they operate for governmental agencies. In these relationships there is a potential not only for exchanges between the independent commercial research laboratories and the contractor operated research laboratories, but between the independent commercial research laboratories and their commercial clients. In reality, this relationship might be perceived as leakage of information from the public sector to the private sector.

Cultural Issues

The cultural issues in the technology transfer networks are significant. To fully understand these issues it is important to examine them empirically. The Intellectual Property (2002) report offers quantitative evidence in the cultural nature of technology transfer networks. Although the report presents a quantitative assessment of networks' performance for the 2001 fiscal year, it offers a great deal of insight into their cultural dynamics. Exhibit 1 presents a key to the names of the individual governmental agencies mentioned in the report and should serve as a key to subsequent analysis.

Exhibit 2 shows that in 2001 DOE disclosed the highest number of inventions (1,479), applied for 1,126 patents, and holds 5,219 patents. DOE applied for patents for 76.0 percent of its disclosed

inventions. The Air Force is second with 139 disclosed inventions, applied for 119 patents, and holds a total of 2,344 patents. In 2001 the Air Force applied for patents for 85.0 percent of its disclosed inventions. The Navy is in third place with 589 disclosed inventions, applied for 451 patents, and holds 2,324 patents. The Navy applied for patents for 85.0 percent of its inventions. It is important to note that DOE, responsible for energy utilization in the United States, leads in disclosing inventions but is lowest of the three in patent applications for its disclosed inventions. The Air Force and Navy are military agencies with their own cultural underpinnings. As a comparison, for example, NASA, a major space agency, only disclosed 696 inventions in 2001, and applied for 302 patents, which constitutes approximately 43 percent of disclosed inventions for a total of 1,368 patents in force. From a cultural standpoint, a major agency such as NASA that is in charge of space exploration would seem to be more concerned with innovation and patented technology. *Nevertheless, the technology transfer behavior of each agency participating in the public sector network contributes to creation of a cohesive culture.*

Royalty income for the major nine agencies listed in Exhibit 2 slightly increased from 1997 to 2001 as shown in Exhibit 3. However, total royalty income for all nine agencies is relatively low in comparison to their individual research budgets.⁴ This finding suggests that, due to strong relationships, a great deal of technology is transferred informally.

Another interesting point in this analysis is the ratio of domestic and foreign patents issued to each agency during the 2001 fiscal year. The National Institute of Health (NIH) received 1.0 foreign patent for every 2.2 domestic patents. The Agricultural Research Service (ARS) received 1.0 foreign patent for every 5.3 domestic patents. And, DOE received 1.0 foreign patent for every 13.3 domestic patents. These figures are presented in Exhibit 4 and they suggest that, from a cultural standpoint, these three agencies are relatively international. This is particularly apparent when compared to the Army that received 1.0 foreign patent for every 53.7 domestic patents. These findings reveal important connections between technology transfers from domestic to foreign sectors. The health and agricultural sectors are more active in foreign technology transfer than the military sector.

The cultural impact of the top nine agencies of the U.S. government is even more interesting when some of the licenses resulting from their patents are compared for the fiscal year 2001 (see Exhibit 5). DOE leads with nonexclusive licenses—497, followed by NIH with 153, and NASA with 23. DOE also leads with partially exclusive licenses—38, followed by NASA with 11, and Navy with 7 licenses. However, the category of exclusive licenses is even more revealing. In this category DOE leads again with 48 exclusive licenses, followed by NIH with 44 licenses, and ARS with 21 licenses. These findings suggest that DOE has a very open culture regarding the granting of nonexclusive licenses. NIH, however, is second in granting both nonexclusive and exclusive licenses. This finding tentatively suggests a sharing culture regarding diffusion of new technology.

Exhibit 6 lists the licenses executed by the nine agencies in fiscal year 2001 by property types. DOE licensed 304 patents and 245 other types of intellectual property. It is not completely clear in the analysis what this number implies. NIH licensed 149 patents and 51 instances of research material were licensed. The Army licensed only 56 patents. No other licenses were issued by the Army.

The number of licenses enforced by the nine agencies as of September 30, 2001 is presented in Exhibit 7. The National Institute of Health awarded 1,152 domestic and 205 foreign licenses (ratio 1.0 foreign for every 5.6 domestic licenses). The DOE leads with 1,866 licenses awarded in the United States with 272 licenses awarded in foreign countries (ratio 1.0 foreign license for every 6.9 domestic licenses). The numbers again indicate a relatively open culture in granting foreign licenses. These observations can be compared to NASA that in the same time period granted 269 undetermined licenses.

Although the overall income from licensing new technology is relatively low, NIH leads with licensing income in the 2001 fiscal year of 46 million dollars followed by DOE with 21 million and by ARS with 3.0 million of dollars in licensing income (see Exhibit 8). These figures suggest that the transfer of technology from the public to the private sector is a relatively profitable business for the socially focused agencies of the United States government.

⁴ Research budgets for the nine individual agencies were not available at the time of writing this presentation. Overall estimates are not necessarily reliable, and, therefore, were not included.

When both the public and private sector networks performances are examined empirically, distinct cultural ties become apparent. These cultural ties generate not only a unique environment within each network, but they also produce both formal and informal relationships that have internal and external impacts on the functioning of each network.

Commercialization

The analysis above presents an interesting picture of the network that is responsible for the transfer of technology and commercialization effort of the United States government. The technology transfer networks are extensive and complex. They involve governmental agencies in the public sector network and commercial entities in the private sector network. The governmental agencies combined produce a considerable number of innovations and attempt to commercialize those innovations. The analysis indicates that the defense industry has a significant number of patents (4,668) that are enforced within the public and private sector network, but it generates limited income from the licenses to these patents (\$1.0 million). At the same time, DOE, NIH, and ARS enforce 5,219 patents receiving \$70.0 million in fiscal year 2001. These findings illustrate the differences between the defense and private market orientations. The defense agencies are not necessarily interested in commercializing innovations developed within the public sector network.

Several observations can be made regarding these relationships with respect to commercialization of new technology within the two networks. First, due to the formal and informal relationships within the networks, there might be a great deal of new technology leakage. Second, due to the nature of the defense industry as a part of the public sector network, and the close cooperation of defense contractors in the private sector network, there might be some voluntary sharing of new technology. And, finally, it might be concluded that some new technology is deemed to be not currently appropriate for commercialization and simply is not offered to the technology transfer and acquisition units in the private sector network for licensing.

Conclusion

Contemporary network theory has been applied mostly to single industrial networks. Seldom is network theory considered in an examination of related networks such as the government managed networks or their interaction with private industrial networks. The two technology transfer networks presented in this case are complex networks from any perspective of network theory. The focal relationships within the networks are clear; however, it appears that the networks are driven by informal relationships. An examination of secondary focal relationships also indicates that perhaps the networks are driven by intermediary actors who facilitate the flow of new technology (know-how and skills) in a more informal and perhaps passive way rather than by a formal technology transfer mechanism. These tentative observations based on a sample of one fiscal year show a need for additional research from the perspective of network theory.

The focal relationship between governmental agencies in the public sector network and commercial entities in the private sector network presents an interesting set of situations that might potentially hinder technology transfer in many major countries. In countries where cooperation between governmental agencies and commercial entities has not been established and universities do not participate in operating research laboratories for either governmental agencies or commercial entities, the country may have only a small chance of bringing new technology into the marketplace. It is also apparent that the informal relationships imbedded in the technology transfer network may be as instrumental in commercializing new technology as the formal relations, if not more.

Recommendations

The case study of technology transfer in one country is an attempt to stimulate additional research in the realm of network theory that includes both the public and private sectors networks. The focal behavior relationships between the two main actors in these networks may be applied to other public sector network projects, not necessarily just to new technology diffusion projects. Attempts to study technology transfer networks concerned with social issues such as the introduction of new health care systems or environmental issues related to land use utilization may also lend themselves to this type of analysis. The important point is that additional studies are needed to develop a better

understanding not only of how these networks evolve but also how of they function if contemporary societies.

Based on an examination of the technology transfer networks, it is apparent that additional studies need to be undertaken. A two-way analysis is suggested. First, detailed case studies need to be prepared and analyzed in order to understand the fundamental components and constructs in the network. The case study research needs to be followed by detailed empirical examination of the formal and informal aspects of the network combined with examination of the effectiveness and efficiency of the network. An extension of network theory into the public sector is becoming imperative, especially in the light of more cooperative attitudes between the public and private sectors in many economies worldwide. It might also be useful and appropriate to develop a comparative case for technology transfer networks in other countries that allocate large research funds for development of new technology.

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Diagram 1—Technology Transfer Networks

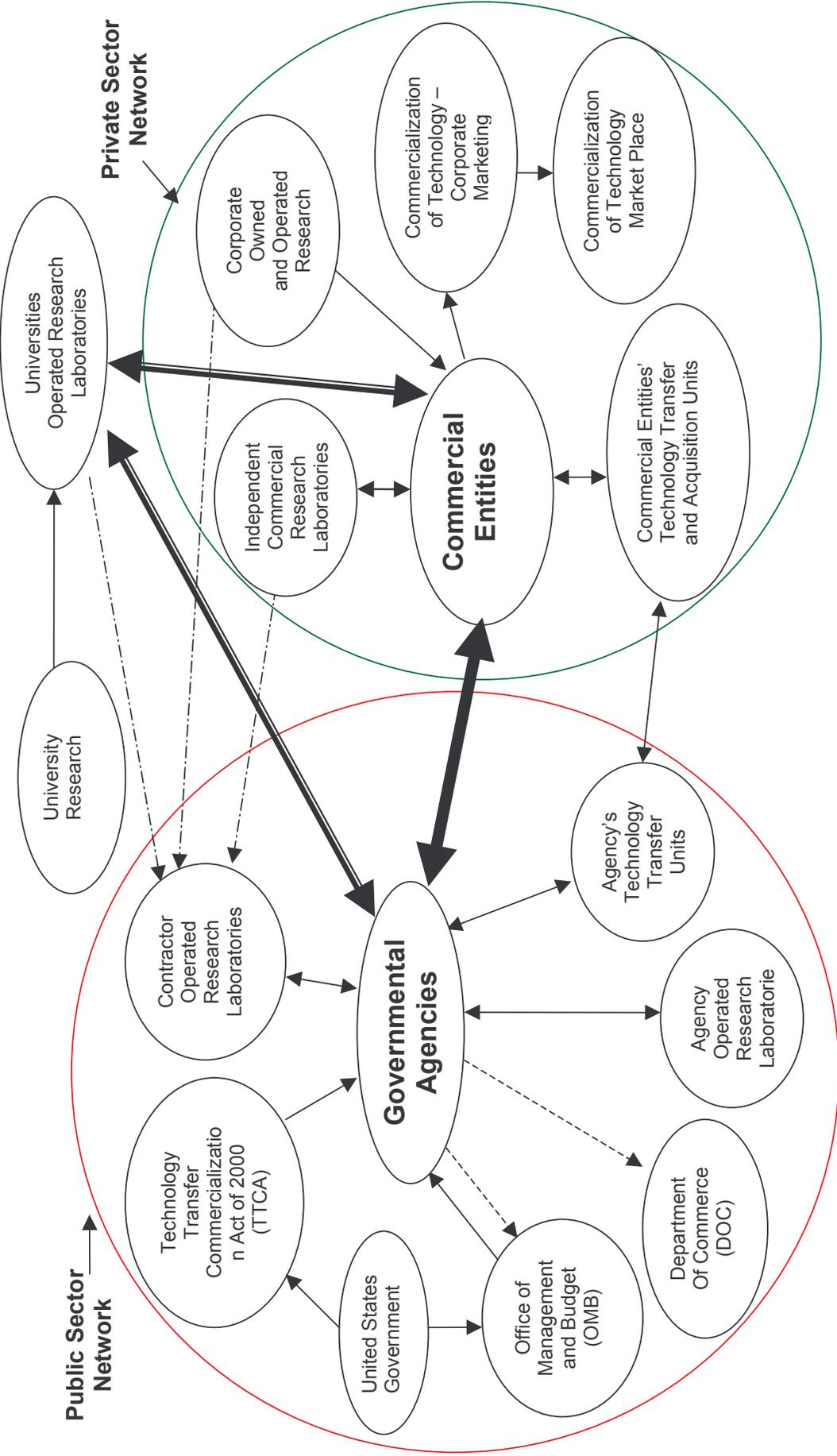
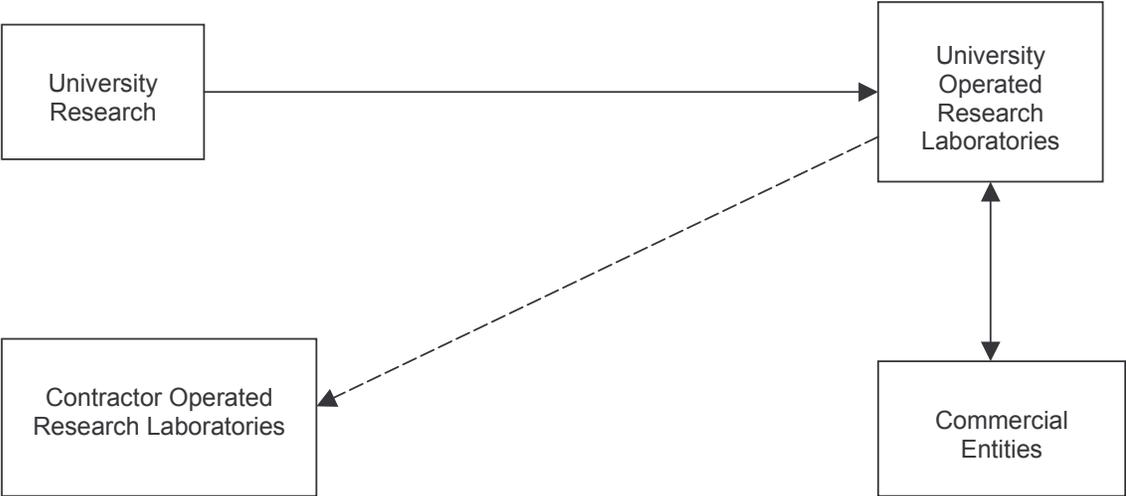


Diagram 2—Networks Components

Network Component #1



Network Component #2

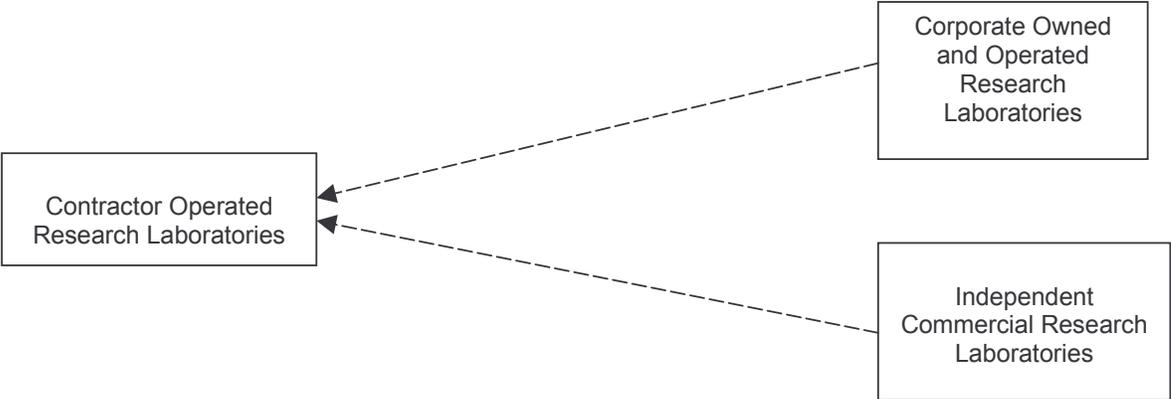


Exhibit 1 Terminology

ARS	Agricultural Research Service
DOD	Department of Defense
DOE	Department of Energy
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OMB	Office of Management and Budget
OTT	Office of Technology Transfer
TTCA	Technology Transfer Commercialization Act of 2000
USGS	United States Geological Survey
USPTO	United States Patent and Trademark Office

Exhibit 2 Inventions and Patent Applications for Nine Federal Agencies in Fiscal Year 2001

Governmental Agencies	Number of Inventions Disclosed	Number of Patent Applications	Number of Applications as Percentage of Inventions Disclosed	Number of Patents in Force*
DOE	1,479	1,126	76.0%	5,219 (1)
NASA	696	302	43.0	1,368
Navy	589	451	77.0	2,324 (3)
NIH	379	330	87.0	2,024
Army	270	343	127.0	1,140
Air Force	139	118	85.0	2,344 (2)
ARS	118	118	100.0	619
USGS	4	16	400.0	42
NOAA	2	3	165.0	10

*As of September 30, 2001.

Source: GAO Report GAO-03-47

Exhibit 3 Total Royalty Income from Nine Federal Agencies for 1997 to 2001 Fiscal Years in Million of the United States Dollars*

Fiscal Year	Total Royalty Income (\$)
1997	45.0
1998	55.0
1999	60.0
2000	71.0
2001	74.0

*Adjusted for inflation

Source: GAO Report GAO-03-47

Exhibit 4
Patents Issued to Nine Federal Agencies
Fiscal Year 2001

Federal Agency	Domestic (U.S.) Patents	Foreign Patents to	Ratio of Domestic to Foreign Patents
DOE	545	41	13.3:1.0
Navy	327	4	81.7:1.0
Army	161	3	53.7:1.0
NASA	152	7	29.4:1.0
Air Force	114	0	114.0:0.0
NIH	99	46	2.2:1.0
ARS	64	12	5.3:1.0
NOAA	1	0	1.0:0.0

Source: GAO Report GAO-03-47

Exhibit 5
Types of Licenses Executed in Fiscal Year 2001

Federal Agency	Nonexclusive	Partially exclusive	Exclusive
ARS	3	7 (3)	21 (3)
Air Force	7	2	8
Army	6	0	8
DOE	497 (1)	38 (1)	48 (1)
NASA	23 (3)	11 (2)	12
NIH	153 (2)	3	44 (2)
NOAA	0	0	1
Navy	13	7	6
USGS	2	0	0

Source: GAO Report GAO-03-47

Exhibit 6
Licenses Executed in Fiscal Year 2001 by Property Type

Federal Agency	Patents	Research Material	Other
ARS	31	0	0
Air Force	17	0	0
Army	56	0	0
DOE	304	0	245
NASA	38	0	8
NIH	149	51	0
NOAA	1	0	0
Navy	26	0	0
USGS	2	0	0

Source: GAO Report GAO-03-47

Exhibit 7
Licenses in Force as of September 30, 2001*

<u>Federal Agency</u>	<u>United States</u>	<u>Foreign</u>	<u>Undetermined</u>
ARS	0	0	245
Air Force	63	0	0
Army	89	12	0
DOE	1,866	272	0
NASA	0	0	269
NIH	1,152	205	0
NOAA	1	0	0
Navy	99	7	0
USGS	6	0	0

* Number of licenses

Source: GAO Report GAO-03-47

Exhibit 8
Licensing Income in Fiscal Year 2001

<u>Federal Agency</u>	<u>In Million of the United States Dollars*</u>
ARS	3.0
Air Force	0.0
Army	1.0
DOE	21.0
NASA	2.0
NIH	46.0
NOAA	0.0
Navy	1.0
USGS	<u>0.0</u>
Total	74.0

* Adjusted for inflation

Source: GAO Report GAO-03-47