SCIENCE AND TECHNOLOGY

SCIENCES ET TECHNOLOGIE

TRANSFERS OF FUNDS FOR RESEARCH AND DEVELOPMENT IN CANADIAN INDUSTRY, 1993

Antoine Rose

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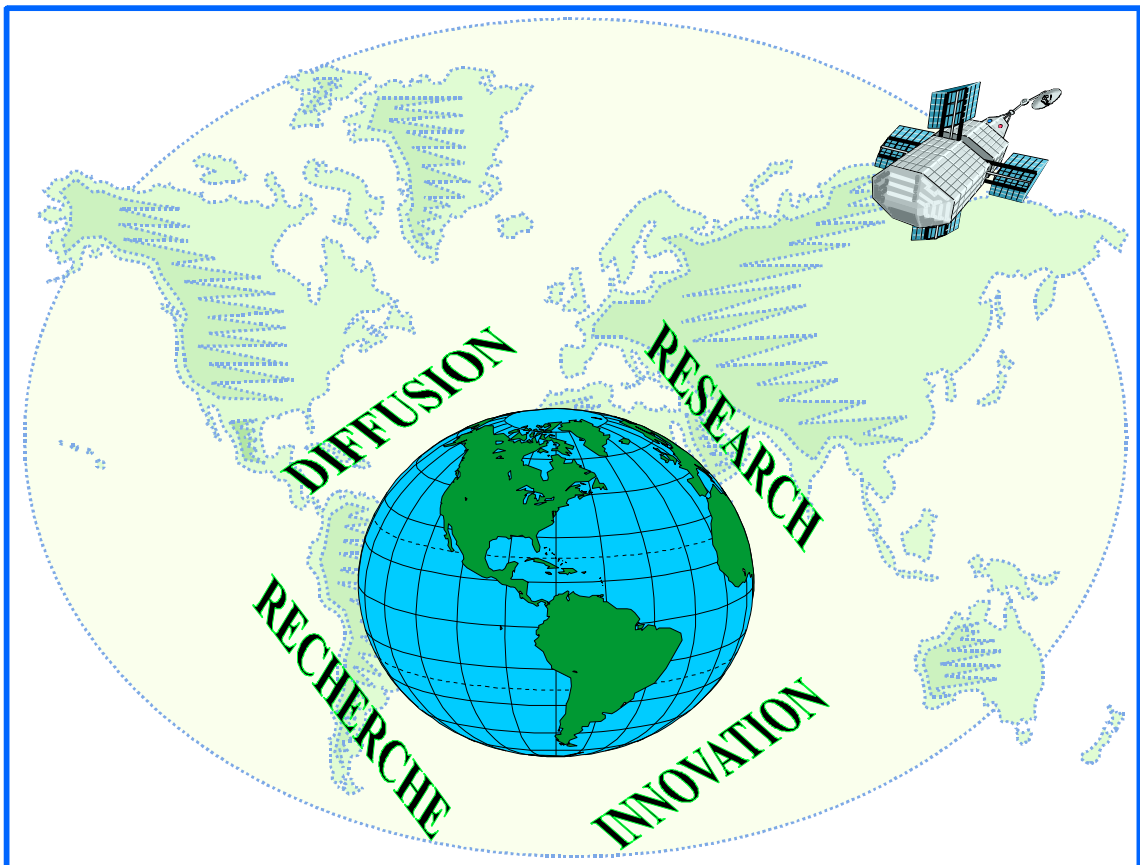

AN INFORMATION SYSTEM FOR SCIENCE AND TECHNOLOGY

SYSTÈME D'INFORMATION SUR LES SCIENCES ET LA TECHNOLOGIE

Statistique Canada Statistics Canada

Canada

TRANSFERS OF FUNDS FOR RESEARCH AND DEVELOPMENT IN CANADIAN INDUSTRY 1993

SCIENCE AND TECHNOLOGY INFORMATION SYSTEM PROJECT

by

Antoine Rose

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THE INFORMATION SYSTEM FOR SCIENCE AND TECHNOLOGY PROJECT

The purpose of this project is to develop useful indicators of activity and a framework to tie them together into a coherent picture of science and technology in Canada.

To achieve this purpose, statistical measurements are being developed in five key areas: innovation systems; innovation; government S&T activities; industry; and human resources, including employment and higher education. The work is being done by Statistics Canada, in collaboration with Industry Canada, and with a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a limited and potentially misleading picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive. More work has to be done to understand the characteristics of innovative and non-innovative firms, especially in the service sector, which dominates the Canadian economy. The capacity to innovate resides in people and measures of the characteristics of people are being developed in industries which lead science and technology activity. In these same industries, measures are being developed on the creation and the loss of jobs as part of understanding the impact of technological change.

The federal government is a principal player in science and technology investing over five billion dollars each year. In the past, it has been possible to say how much and where the federal government spends on S&T. The next report, to be released early in 1997, will begin to show what the S&T money is spent on. As well as offering a basis for a public debate on the priorities of government spending, this information will provide a context for reports of individual departments and agencies on performance measures which focus on outcomes at the level of individual projects.

By the final year of the Project, 1998-99, there will be enough information in place to report on the Canadian system of innovation and show the role of the federal government in that system. As well, there will be new measures in place which will provide a more complete and realistic picture of science and technology activity in Canada.

CONTACTS FOR MORE INFORMATION

S & T Redesign Project

Director
Dr. F.D. Gault (613-951-2198)

An Information System for Science and Technology

Chief, Indicators Development
Dr. Frances Anderson (613-951-6307)

Chief, Data Integration Projects
Daood Hamdani (613-951-3490)

Survey Development Officer
Rachel Bernier (613-951-2582)

Project Development Officer
Antoine Rose (613-951-9919)

Science and Technology Section

Project Leader, Private Sector
M. Boucher (613-951-7683)

Senior Project Officer
D. O'Grady (613-951-9923)

Project Leader, Public Sector
B. Plaus (613-951-6347)

Senior Project Officer
J. Thompson (613-951-2580)

FAX: (613-951-9920)

Working Papers

The Working Papers publish research related to science and technology issues. All papers are subject to internal review. The views expressed in the articles are those of the authors and do not necessarily reflect the views of Statistics Canada.

Highlights

The Canadian business sector spent nearly $6,548 million on intramural research and development in 1993. Over $516 million was transferred between organizations for R&D activities. Among these organizations, we find principally business enterprises but also some research institutes.

More than half of these funds, or $295 million, was transferred between related firms. Less than half of all R&D transfers, or 40%, were between companies in the same industry.

The 190 companies that were recipients of R&D funds received an average of $2.7 million while the 429 fund-supplying firms paid out an average of $1.2 million for R&D.

The average value of R&D funding transfers increases with company size but the propensity to be more or less involved in R&D transfers does not appear to be affected by company size. Many small companies (revenue under $1 million) which perform very little R&D pay out funds to other companies for their R&D needs.

Services industries have performed close to two thirds of R&D resulting from a fund transfer. Two activity sectors, telecommunication services and business services, monopolized most of these fund transfers.

R&D alliances or outsourcing?

The alliance and outsourcing concepts are not new. Companies have long turned to these arrangements to undertake a wide range of activities from service contracts to agreement on a joint submission to a call for tenders to integrating activities through a merger.

The data presented do not allow the determination of the exact nature of the contractual relation at the origin of the R&D fund transfers. We observe a fund transfer which reveals the existence of a scientific and technological knowledge flow. The present study provides a cartography of these fund transfers.

The following discussion on the alliance concept provides an explanatory framework, among other possible ones, for the R&D fund transfers. However, this does not imply that all R&D fund tranfers are being considered as alliances nor as outsourcing. Literature on the concept of alliances is abundant and proposes explanations for firms motivations.

In the field of research and development (R&D), companies often turn to specialized research institutes. The pulp and paper industry and the computer and telecommunications field are examples. These institutes do research in pre-competitive areas which are of interest to contributors to the institutes.

The relationship between companies and institutes is complementary. Companies perform their own R&D and use institutes for two types of research: the overall advancement of knowledge to a pre-competitive level (where the results may be relatively inaccessible for the company but are nevertheless necessary to increase its knowledge base) and ad hoc research, which may be done on contract, for which the company feels it is more profitable to use the expertise of an outside party.

In order to carry out its production role, the company needs a certain knowledge base. To remain competitive or advance, the company must maintain and develop this base. This assumes strategic choices, involving elements of risk, which will in part determine the company's future development. R&D is one of the ways this knowledge base can be modified. Companies do, however, have a number of strategic options: they can carry out some or all of their own R&D work, sub-contract part of it or collaborate with others.

We have used the example of collaboration between research institutes and companies to illustrate one of the strategies companies use to increase their knowledge base. In this study, we mainly examine the links established between companies for the performance of R&D. When transferring funds, firms are de facto establishing a link. However, only a close look at the way firms constructed that link would permit one to conclude definitively on the presence of an alliance or on another type of contractual relation.

The transfers of funds corresponds to a transfer of knowledge which, by the nature of an R&D project, was unknown and uncertain at the time the agreement was set-up. Because of the specific nature of the good being transferred for a monetary counterpart (knowledge resulting from R&D activities), an important level of confidence must exists between partners. The results and value of R&D activities are, by definition, uncertain, if not unknown. The fund supplier must estimate, a

priori, the value of the knowledge to be transmitted. Confidence is necessary for such a relation to exist.

There is no single definition of an alliance. It is generally formed in accordance with the specific goals of a study. The Frascati Manual (OECD,1993), which establishes the basic criteria and definitions for collection of data on R&D and international comparisons, does not deal specifically with alliances. As explained subsequently in the methodology section, the Manual gives only minimal instructions on handling flows of funds for R&D.

Several authors have already studied the question of R&D alliances under various angles; for example, Hagerdoorn (1993), Niosi, J. (1995), Wegberg, M. Van and Witteloostuijn A. Van (1995).

The basic problem we face in connection with alliances is having to explain the apparent contradiction between the fact that two or more firms or economic agents enter into a cooperative relation when in fact these organizations are in competition.

The scientific and technological knowledge derived from R&D is intangible and develops in a three-dimensional space depending on whether it is codifiable or remains tacit, is public or private, or whether access is open or restricted (David and Foray, 1995). If companies are to prosper, they need a constantly renewed knowledge base; however, because of the nature of knowledge, companies cannot appropriate all the knowledge generated. This leads to two possible results: companies attempt to only invest in creating knowledge that they can appropriate, or race to be first with innovation which leads to duplication of effort (Arrow, 1962).

Alliances are a partial response to this situation. They allow companies to undertake more generic research projects and generally improve their stock of knowledge. Back in the competitive arena, the companies retain mastery over their respective choices in developing and introducing innovations, marketing, capital investment and acquisition of equipment.

One characteristic of most studies on alliances is that they are mainly concerned with companies involved and competing in the same sector of activity. Less work has been done on R&D alliances between firms whose areas of expertise are complementary.

In *The New Production of Knowledge* (Gibbons et al, 1994), the authors describe the formation of alliances as the result of two possible trajectories: the first reverses the trend towards integration of activities by more decentralized firms where costs are exported outside the firm through outsourcing, and in the second firms opt for a collaborative rather than a centralizing approach to R&D. Decentralization is mainly achieved using new information technologies.

Collaboration between firms normally in competition is paradoxical and can be explained using a two-stage structure. At the first level, the firms are in competition for market share and emphasize product quality and differentiation. At the second, the firms are generally under constant pressure to innovate. This innovative capacity is based on knowledge and skill and is aimed at maintaining a competitive edge. Competition at this level is thus competition on the scale of the industry sector in which the firm operates. This will depend on the group, hence the need for alliances. This is particularly true in the R&D field, which involves knowledge transfers.

Other factors are also suggested to explain R&D alliances, such as globalization, which pushes firms to try to develop globally integrated systems, and the need to share the ever-increasing costs of the race for technology (Kumar and Magun, 1995). However, these factors do not explain why competing firms form alliances.

Major existing consortia in the U.S., such as MCC (Microelectronics and Computer Technology Corporation) and Sematech (Gibson and Rogers, 1994; Tassey, 1992) have also been studied and the paradox between collaboration and competition again examined. The main argument in favour of creating a consortium is the desire to create a synergy between members that will bring positive outside benefits.

This idea is also discussed by Wegberg and Witteloostuijn (1995) for whom cooperation on R&D is first of all a question of efficiency, as it gives both parties access to the positive outside benefits generated by collaboration, along with reduced costs, risk-sharing and lower overhead. It is then necessary to develop a balance between the benefits from increased efficiency through cooperative R&D and the costs associated with reducing competition between parties.

The first chapter of Niosi (1995) develops a theory of technological alliances. Some of the factors explaining alliances mentioned are: seeking economies of scale (which compares to the notion of efficiency through cost-sharing), reducing risk and uncertainty and acquisition of complementary assets (this notion may be combined with imperfections in the information market to mean seeking greater access to other types of expertise). These factors are, however, more frequently mentioned in cases of collaboration between firms in the same industry sector. Vertical alliances between users and producers can be explained by the desire of producers to acquire the knowledge users obtain through *"learning-by-using"* (Rosenberg, 1979).

The need to improve efficiency in research through sharing of costs and risks is a recurring explanation, used mainly to explain alliances between competitors. It is difficult to attribute alliances simply to the need to acquire user knowledge. By forming R&D alliances, companies can be seeking complementary knowledge. With today's multi-faceted technological development, there is something that goes beyond the need to share costs and risk; it is impossible and counterproductive for firms to attempt to produce all the knowledge they need. One way to fill the gap is to become part of a network with other firms through R&D alliances.

In this study, we consider as an R&D transfer any fund transfers for R&D between two partners. This transfer is not qualified, i.e. we do not know what type of relation exists between the two parties to the funds transfer. It may be a simple ad-hoc contractual relation for a specific, limited project; the arrangement may be due to other relationships between the parties involved, or the transfer may be the visible aspect of a well-established partnership. Similarly, we have no information on how long the relationship lasts.

These transfers nevertheless give some idea of the extent, number and importance of the visible aspects of these relations and the directions they take. Insofar as an alliance can be strictly define as a joint and bilateral effort to create and exchange knowledge, one can certainly argue that the transfers described here do not, strictly speaking, represent alliances. Conversely, it would be erroneous to assert that the transfers observed are solely service contracts.

The data being considered involves the transfers of funds for R&D purposes. All or at least a part of these transfers reveal the existence of a network for which can be identified actors, privileged

directions, and transfer intensity. However, a knowledge transfer does not necessarily mean a monetary transfer. Transactions with no transfer of funds are not visible within this study. We invite the reader to read the methodology section to understand the criteria which guided the statistical treatment of the transfers.

How important are R&D fund transfers?

This study covers only the companies that completed the detailed 1993 Survey questionnaire on Research and Development in Canadian Industry. Transfers between small companies which completed the short questionnaire are not covered. All of these transfers between small firms represent $31.4 million; and this amount is not included in the tables that follow except in table 1. As shown in Table 1, over $516 million was transferred between Canadian firms for R&D in 1993. This represented a little over 7% of total spending on industrial R&D in 1993. A little over half of these funds were transferred between related firms. Of the 590 transactions, 429 firms supplied funds to 190 R&D performers. Even though the investment in terms of a ratio of total intramural R&D spending might seem high, it should be borne in mind that the firms that participated in these R&D transfers formed a major proportion of all R&D performers. Firms that performed R&D as part of transfers also spent a total of $2.7 billion to carry out R&D, while the firms which financed the transfers performed over $3.5 billion worth of intramural R&D.

Table 1 also provides information on small firms and transactions not covered by this study. With $31.4 million of funds transferred, this non-covered part represent only 6% of all R&D fund transfers. Note that the proportion of R&D fund transferred over intramural R&D performed is high for these firms.

Table 1
Transfers of funds for R&D, 1993
Principal statistics

	Fund recipients	Fund suppliers
Statistics on firms and transactions covered by this study		
Funds exchanged ($000,000)	516.5	
Funds exchanged between related firms ($000,000)	295.3	
Number of firms involved		
Total	190	429
Related firms	45	70
Number of transactions		
Total	590	
Related firms	77	
Total intramural R&D ($000,000)	2,658.6	3,454.6
Total revenues ($000,000)	70,854.4	130,610.9
Statistics on small firms and transactions not covered by this study		
Funds transferred ($000,000)	31.4	
Number of firms involved		
Total	189	Not available
Related firms	68	Not available
Total intramural R&D ($000,000)	45.9	Not available
Total revenues ($000,000)	645.5	Not available

Source: Industrial R&D Survey, Statistics Canada

By industry

Most industries are involved in transfers of funds for R&D to various degrees. Those extensively involved fall into two groups: industries linked to information technologies (telecommunication equipment, computer services, communications, etc.) and industries providing services (engineering, scientific and management consultants).

Table 2 compares the amounts transferred for R&D in terms of funds received for performance of R&D, whether intramural or extramural. The amounts are also compared to total spending on intramural R&D by the companies that received or paid these funds. This table should be viewed together with Table 3. Looking at funds received, 36 firms in the communications, computer services and other services industry received $176.4 million for R&D performed in-house. At the same time, these firms performed $224.7 million worth of intramural R&D, for a ratio of 79%.

Examining the ratio of amounts spent on R&D transfers to total R&D spending, we see significant differences from one industry to another. Among performers (fund receivers), the highest proportion goes to communication, computer and other services, where 79% of R&D performed in-house was carried out with funds from other companies. Similarly, 91 firms in this industry paid (fund suppliers) $249 million for R&D performed by other companies, compared with $502.5 million spent on intramural R&D, for a ratio of 50%.

Table 2
R&D fund transfers by industry, 1993
Value

	Transfers	Performance of R&D	Ratio
Firms receiving funds	**516.5**	**2,658.6**	**19%**
	($000,000)		
Agriculture, mines and oil wells	45.0	83.4	54%
Wood, paper and printing	6.2	58.7	11%
Semi-processed metals	1.9	119.2	2%
Transport machinery and equipment	14.6	395.0	4%
Telecommunications equipment, electronic equipment and office machine	87.9	1084.3	8%
Non-metallic minerals, oil and coal products	0.6	80.1	1%
Pharmaceuticals and medicines, and other chemicals	6.4	32.1	20%
Other manufacturing	11.3	37.0	31%
Electricity	12.4	224.5	6%
Engineering and scientific services, and management consultants	153.8	319.6	48%
Communications, computer and other service industries	176.4	224.7	79%
Firms supplying funds	**516.5**	**3,454.6**	**15%**
	($000,000)		
Unidentified industry code	64.6	Not Available	Not Available
Forestry, mining and oil	21.5	90.8	24%
Rubber, plastic and textile products	0.7	42.9	2%
Wood, paper and printing	1.7	74.9	2%
Semi-processed metals	1.3	96.6	1%
Transportation equipment and machinery	32.8	646.9	5%
Telecommunications, electronic and electrical equipment	38.1	1,303.2	3%
Non-metallic mineral and oil products	16.0	104.6	15%
Pharmaceuticals and medicines	27.6	228.8	12%
Other manufacturing	14.6	5.9	249%
Electricity and other utilities	14.0	213.1	7%
Engineering and scientific services, and management consultants	34.5	144.5	24%
Communications, computer and other service industries	249.0	502.5	50%

Source: Industrial R&D Survey, Statistics Canada

Table 3 shows the number of firms involved and the number of transactions. The most intense activity (in terms of number of firms and transactions) is in the management services area (engineering, scientific and management consultants) and communication, computer and other service industries.

Table 3
R&D fund transfers by industry, 1993
Transactions

	# firms	# transactions	Ratio
Firms receiving funds	**190**	**590**	**3.1**
Agriculture, mines and oil wells	12	50	4.2
Wood, paper and printing	6	37	6.2
Semi-processed metals	3	7	2.3
Transport machinery and equipment	7	13	1.9
Telecommunications equipment, electronic equipment and office machines	13	31	2.4
Non-metallic minerals, oil and coal products	4	11	2.8
Pharmaceuticals and medicines, and other chemicals	5	11	2.2
Other manufacturing industries	14	26	1.9
Electricity	4	35	8.8
Engineering and scientific services, and management consultants	86	275	3.2
Communications, computer and other service industries	36	94	2.6
Firms supplying funds	**429**	**590**	**1.4**
Unidentified industry code	137	194	1.4
Forestry, mining and oil	28	37	1.3
Rubber, plastic and textile product	4	4	1.0
Wood, paper and printing	14	19	1.4
Semi-processed metals	6	7	1.2
Transportation equipment and machinery	17	28	1.6
Telecommunications, electronic and electrical equipment	27	42	1.6
Non-metallic mineral and oil products	8	15	1.9
Pharmaceuticals and medicines	33	45	1.4
Other manufacturing	11	11	1.0
Electricity and other utilities	10	28	2.8
Engineering and scientific services, and management consultants	43	46	1.1
Communications, computer and other service industries	91	114	1.3

Source: Industrial R&D Survey, Statistics Canada

Characteristics of Transfers

Company size by revenue

It is difficult, based on Table 4, to conclude that size has a determining influence on the volume and quantity of R&D transfers. What is influenced by size is the average investment of each firm in these transfers. The largest firms tend to invest the largest amounts. It can, nevertheless, be seen that firms of all sizes are involved in transfers, as an R&D performer or as an R&D funder.

Looking at firms which financed R&D performed by other firms (payments), it is interesting to note the large number of small firms (revenue under a million dollars) which paid for R&D while spending very little on R&D performed in-house. Similarly, we may infer that most unidentified companies investing small amounts were small companies, and these companies performed no R&D.

Being small does not eliminate a company's need to maintain and increase its stock of knowledge. These small firms clearly used a different strategy. They transferred funds to other firms who have the R&D expertise they need. It is noteworthy that, in the payments section in Table 4, firms with revenues under $1 million performed very little R&D yet engaged over $84.2 million in payments for R&D.

Table 4
R&D fund transfers by company size, 1993

Size of revenues	Number of firms	Transfers of funds	R&D performed in-house
		$000,000	
Firms receiving funds			
Non-commercial org.	17	50.9	122.0
Less than $1 million	54	15.5	35.1
$1-9 million	61	77.1	144.7
$10-99 million	30	145.9	378.2
$100-399 million	7	22.9	376.9
$400 million and over	21	204.3	1,601.8
Total	190	516.5	2,658.6
Firms supplying funds			
Unidentified companies	137	64.6	Not available
Non-commercial org.	9	5.7	76.0
Less than $1 million	125	84.2	3.4
$1-9 million	22	4.8	58.7
$10-99 million	39	53.9	326.8
$100-399 million	41	80.7	652.2
$400 million and over	56	222.7	2,337.5
Total	429	516.5	3,454.6

Source: Industrial R&D Survey, Statistics Canada

Supplier or performer?

In most industries, there are companies that have funded or performed R&D; however, examining the differences between funding and performance for each industry shows that some industries provide funds for R&D while others tend to be R&D performers.

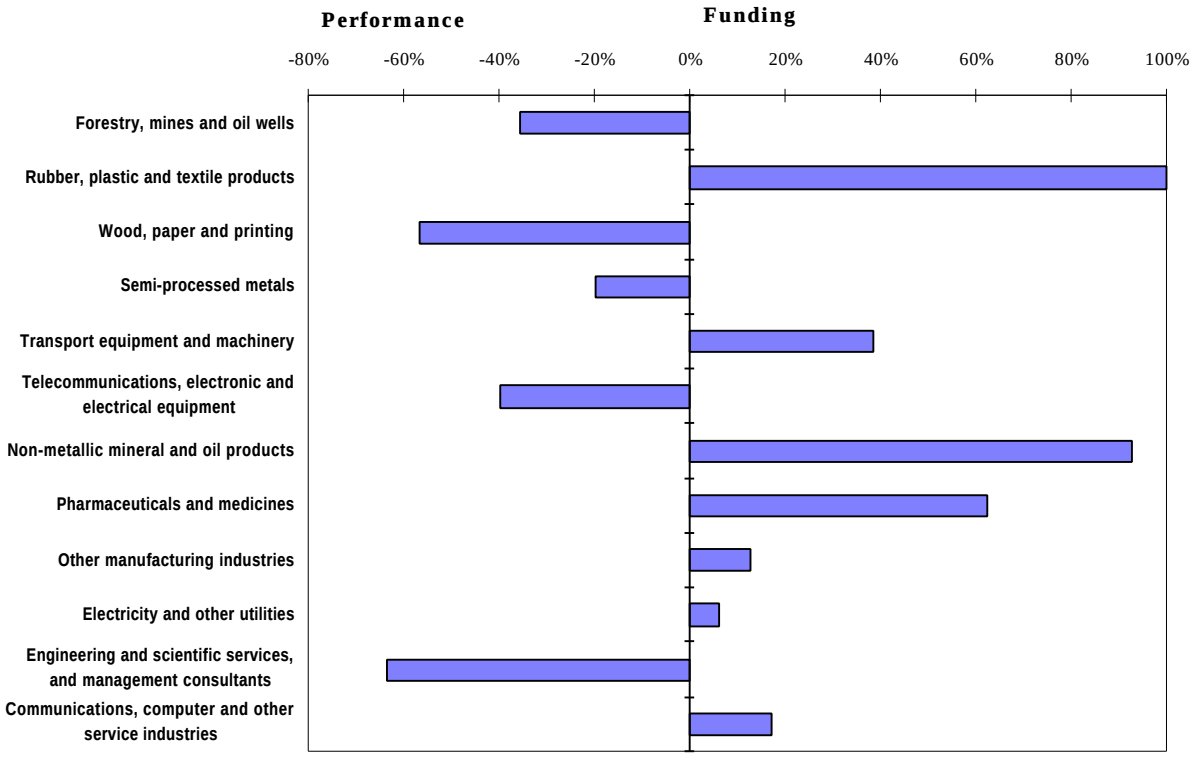
The histograms in Chart 1 show the coverage rate, i.e. the ratio between funding and performance for each industry on all transfers in which that industry is involved. The formula used is as follows:

$$Rate_i = \frac{funding_i - receipts_i}{funding_i + receipts_i}$$

Where the result is a coverage rate, funding is the value of funds supplied to other companies for performance of R&D and receipt is the value of funds received from other companies for R&D. The result may vary by ±100% where -100% means that a given industry is only involved in transfers for R&D performance without providing any funding while +100% indicates that the industry only provided funds for R&D transfers.

The results shown in the chart are interesting. For half of the industries, trends are quite pronounced, since the coverage rate is close to ±40%. It can also be seen that engineering, scientific and management consultants are basically R&D performers receiving funds from other industries. Conversely, the rubber, plastic and textile products, non-metallic minerals and oil products, and pharmaceutical and medicine industries provide funds for R&D performed by others.

Chart 1
Propensity to perform R&D vs funding of R&D, 1993



Source: Industrial R&D Survey, Statistics Canada

Industrial Dynamics

Inter-industry relations

With tables 5 and 6, we come to the crux of our study of inter-industry transfers. Table 5 gives the value of inter-industry transfers while Table 6 shows the number of corresponding transactions. To ensure respondent confidentiality, many of the values in Table 5 were replaced by intervals, which nevertheless allows us to appreciate the magnitude of transfers. For the same reasons, information are not presented with the same degree of disaggregation as in the Statistics Canada publication *Industrial Research and Development* (Catalogue No. 88-202-XPB). Details of the industrial groups used is provided in the appendix, along with the corresponding Standard Industrial Classification groups (SIC 1980).

The most intense transfers are between companies in communications, computer and other services and engineering, scientific and management consultants, both in terms of the amounts transferred and the number of transactions. As explained above, one of the reasons for transfers of funds is the possibility of increasing efficiency by combining expertise and this is done using new information technologies, so it comes as no surprise that the most intense activity is in industries related to the service sector in information technologies.

In addition, transfers between firms in the same industry sector, and thus between potential competitors, represent 44% of all R&D transfers. The remainder (56%) is between firms in different industries. The majority of transfers of funds for R&D are between non-competing companies.

One service industry group, engineering, scientific and management consultants, received a quarter of all R&D fund transfers. In other words, this sector receives almost half of all the funds transferred between firms in different industries. By contracting with business service firms, providers of funds are increasing their access to a broader range of expertise.

Table 5
Input/output matrix for transfers of Canadian funds for R&D, 1993
Figures in $000

Payment of funds for R&D

Receipt of R&D funds — **Industries**	**Total**	Unidentified industry	Forestry, mines and oil wells	Rubber, plastic and textile products	Wood, paper and printing	Semi-processed metals	Transport equipment and machinery	Telecommunications, electronic and electrical equipment	Non-metallic mineral and oil products	Pharmaceuticals and medicines	Other manufacturing industries
Total	**516,508**	**64,559**	**21,487**	**729**	**1,720**	**1,292**	**32,802**	**38,147**	**15,988**	**27,632**	**14,635**
Agriculture, mines and oil wells	**44,987**	**2,198**	*(5)*		*(1)*		*(1)*	*(1)*	*(5)*	249	*(2)*
Wood, paper and printing	**6,184**	**4,286**			656	*(2)*	*(1)*	*(1)*	*(1)*	*(1)*	
Semi-processed metals	**1,926**	*(3)*									
Transport machinery and equipment	**14,557**	*(2)*			*(2)*		*(3)*				
Telecommunications equipment, electronic equipment and office machine	**87,940**	*(3)*					*(5)*	**15,313**			*(5)*
Non-metallic minerals, oil and coal products	**611**	*(1)*	*(2)*				*(1)*		*(2)*	*(1)*	
Pharmaceuticals and medicines, and other chemicals	**6,361**	*(2)*		*(1)*						*(3)*	
Other manufacturing	**11,334**	**1,547**					*(4)*	*(2)*			*(2)*
Electricity	**12,406**	*(4)*				*(1)*		*(3)*	*(1)*	*(1)*	
Engineering and scientific services, and management consultants	**153,813**	**31,499**	**3,488**	*(2)*	748	*(2)*	*(3)*	**12,137**	*(3)*	**14,553**	766
Communications, computer and other services	**176,389**	**12,639**				*(1)*	*(3)*	**6,038**	*(1)*	*(4)*	*(2)*

1) $99,000 or less
2) $100-999,000
3) $1-4.9 million
4) $5-9.9 million
5) $10-19.9 million
6) Over $125 million

Table 6
Input/output matrix for transfers of Canadian funds for R&D, 1993
Transactions

R&D payments

Industries	**Total**	Unidentified industry	Forestry, mines and oil wells	Rubber, plastic and textile products	Wood, paper and printing	Semi-processed metals	Transport equipment and machinery	Telecommunications, electronic and electrical equipment	Non-metallic mineral and oil products	Pharmaceuticals and medicines
Total	**590**	**194**	**37**	**4**	**19**	**7**	**28**	**42**	**15**	**45**
Agriculture, mines and oil wells	**50**	12	12		1		1	1	4	3
Wood, paper and printing	**37**	16			8	1	1	1	1	1
Semi-processed metals	**7**	5								
Transport equipment and machinery	**13**	2			1		6			
Telecommunications equipment, electronic equipments and office machine	**31**	3					3	8		
Non-metallic minerals, oil and coal products	**11**	2	2				1		1	1
Pharmaceuticals and medicines, and other chemicals	**11**	3		1						5
Other manufacturing	**26**	10					2	4		
Electricity	**35**	17				2		7	1	1
Engineering and scientific services, and management consultants	**275**	95	23	3	9	3	9	10	7	31
Communications, information systems and other service industries	**94**	29				1	5	11	1	3

R&D Operations

Conclusion

The study of R&D fund transfers is directly related to the concept of a "national system of innovation" (Lundvall, 1992); this concept applies the notion of system to the field of science and technology where national, cultural, state and political institutions interact. The central focus of this system is scientific and technological knowledge including creation, production, dissemination and transformation processes, not only at the economic and political levels but in social and cultural fields as well.

We as yet know little about the transfers between participants in the national innovation system, We can now add to studies on the use of patents and on scientific publications data on transfers of funds between companies for R&D. Statistics on the use of patents provide information on the dissemination of inventions and publications tell us about the interactions between researchers.

Funds for R&D are transferred between firms in the area of R&D in Canada. These transfers are not uniformly distributed but have preferred directions. The information technology sector is one example: telecommunications firms work with equipment manufacturers and software designers. In such collaborations, we also find a significant mix of manufacturing and service companies. But even more important, over half the transfers took place between firms in different industries. There are at least two possible explanations for these transfers: the desire to acquire part of the technological know-how of the other party in a client/supplier relation, and the use of sub-contracting some R&D work out to service-industry companies.

This study has dealt with flows of R&D funds between firms operating in Canada. These make up a major share of transfers; however, to obtain a more complete picture, we would need to include universities, governments, hospitals and research institutes. In the same vein, little attention was paid to the international component. The extent of international R&D fund transfers should also be examined.

Methodology

This study is based on an analysis of data from the 1993 Survey of Research and Development in Canadian Industry and provides an examination of transfers of funds between companies as reported on the detailed questionnaires. Some information on fund transfers are also reported by smaller companies which completed the short survey questionnaire; however, this information is not included in our study.

Following the first preliminary study on R&D transfers (Rose, 1994), the detailed survey questionnaire was modified to yield better collection of information on transfers of funds for R&D. The universe of companies receiving the detailed questionnaire was also modified to ensure reaching companies involved in fund transfers for R&D. A special effort was made to follow up with companies so as to obtain complete, detailed information.

In the detailed survey questionnaire, respondents were asked to give the name of organizations which supplied or received funds for R&D. This information was checked and encoded. We also attempted to reconcile statements by respondents. For example, if Company A made a payment for R&D to Company B, we should find in Company B's reply a trace of funds from Company A. For transactions involving amounts greater than a million dollars, we made telephone calls to attempt to reconcile information.

Despite all our efforts, there were relatively few replies that corresponded perfectly between two respondent companies. There were three main types of cases: a respondent declared a source of funds for which there was no corresponding payment, the reverse of this situation, and the two companies involved in a transfer declared different amounts. We thus need some criteria to re-establish the correspondence between sources of funds and payments for R&D.

The Frascati Manual (OECD, 1994) suggests two conditions, which must both be obtained, to identify flows of funds for R&D:

- There must be a direct transfer of resources.
- The transfer must be both intended and actually used for R&D (art. 368).

The Manual also suggests two ways to measure funds transfers for R&D: use of R&D performers' statements regarding sums received from a unit or organization for intramural R&D, or use of statements regarding extramural expenditures corresponding to the amounts one unit states having paid to another unit to carry out R&D (art. 366). The first approach is strongly recommended (art. 367).

These criteria are based on the premise that the R&D performer is in the best position to determine whether the funds declared were actually used to carry out R&D. The same criteria were used for this study on flows of funds for R&D. In all cases where statements showed different amounts, the statement of the R&D performer was chosen. Thus, any Canadian payments for R&D for which no performer declared a corresponding source of funds were not included. Conversely, for all sources of Canadian funds declared by performers, corresponding payments were assigned to statements by the units making these payments.

Clearly in cases of payments where no performer declared a corresponding amount, we may deduce that part of the funds transferred were probably used for R&D activities. Verification with some of the companies involved yielded cases where performers had omitted some payments used for R&D from their replies. Since we were unable to check each reply individually, we maintained the policy of giving priority to statements by R&D performers.

Appendix

Description	SIC-E (1980)
Receipt of funds	
Agriculture, mines and oil wells	0111-0239, 0611-0619, 0621-0633, 0811-0821, 0921-0929, 0711-0712
Wood, paper and printing	2511-2599, 2711-2799, 2811-2849
Semi-processed metals	2911-2941, 2951-2999
Transport machinery and equipment	3111-3199, 3211, 3231-3259
Telecommunications equipment, electronic equipment and office machines	3351, 3352, 3359, 3361-3369
Non-metallic minerals, oil and coal products	3551-3599, 3611-3699
Pharmaceuticals and medicines, and other chemicals	3741, 3711-3731, 3751-3799
Other manufacturing	1011-1099, 1711-1719, 2431-2499, 3011-3099, 3911-3914, 3921-3999
Electricity	4911, 4921-4999
Engineering and scientific services, and management consultants	7751-7759, 7771
Communications, computer and other service industries	4011-4499, 4811-4842, 5011-5999, 6011-6921, 7011-7611, 7721-7722, 7711, 7712, 7731-7749, 7761, 7791-9999
Payment of funds	
Unidentified industry code	Not available
Forestry, mines and oil	0611-0619, 0921-0929, 0711-0712
Rubber, plastic and textiles	1511-1599, 1611-1699, 1811-1999
Wood, paper and printing	2511-2599, 2711-2799
Semi-processed metals	2911-2941, 2951-2999
Transport machinery and equipment	3111-3199, 3211, 3231-3259, 3261-3299
Telecommunications, electronic and electrical equipment	3351, 3352, 3359, 3361-3369, 3311-3341, 3371-3399
Non-metallic mineral products and oil	3551-3599, 3611-3699
Pharmaceuticals and medicines	3741, 3711-3731, 3751-3799
Other manufacturing	1711-1719, 2431-2499, 3011-3099, 3911-3914, 3921-3999
Electricity and other utilities	4911, 4921-4999
Engineering and scientific services, and management consultants	7751-7759, 7771
Communications, computer and other service industries	4011-4499, 4511-4799, 4811-4842, 5011-5999, 6011-6921, 7011-7611, 7721-7722, 7711, 7712, 7731-7749, 7761, 7791-9999

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