AN EMPIRICAL STUDY OF THE INDUSTRIAL RESEARCH AND DEVELOPMENT INCENTIVES ACT (IRDIA) OF CANADA

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Introduction:

The objective of this study is to investigate empirically the effects of the Industrial Research and Development Incentives Act (IRDIA) of Canada on the research and development (R&D) activities of Canadian private enterprises. An incentive is defined as a goal that motivates us or affects our level of motivation (Houston, 1985). Hull introduced the concept of "incentive motivation," which is when our level of motivation seems to be increased as the size of the reward is increased and as the attractiveness of that reward is increased (Brody, 1983, p. 36). Incentives such as IRDIA may motivate organizations by pulling them toward more attractive and sizable goals. This study is only a specific example of broader research as to the effects of governmental incentives to promote research and development activities of private enterprises. The Canadian program was chosen because during the IRDIA years (1967-1976) Canada had one of the most generous sets of tax incentives and governmental grants for R&D work (McFetridge and Wards, p. 90; Kaplan et al., 1976, Ch. 1, p. 34). Even though there have been many economic studies of governmental support of R&D in the private sector,

"In general, one can safely say that there has been almost no evaluation of the effectiveness (i.e., behavioral studies) of governmental policies for stimulating R&D" (Kaplan, et al., 1976, Executive Summary, p. 2).

The preceding observation is the driving force behind this study, and the emphasis is on behavioral aspects of IRDIA and not economics. For example, studies by Broadbent (1971) and Glucksberg (1962) appear to support a Hullian theory of incentives; that is, the presence of financial incentives increases motivation. Therefore this study addresses the question of whether the incentive objectives of IRDIA were met or not.

Rationale for the Study:

The case for and against governmental incentives (intervention) for R&D activities is well argued in the literature. The case for governmental intervention is that the social rate of return from R&D is higher than the private rate of return; if left solely to private initiative and investment, there will be an under-allocation of resources to innovative activities (Baty, 1964; Groosfield & Heach, 1966; Horowitz, 1962; Morrissey, 1971). The disparity between social and private returns to R&D is due to (i) Imperfect appropriability of results; the innovator is not able to capture the full economic gain from his invention. (ii) Uncertainty; the economic use of output from innovative investments may be so unsure that many firms, even large ones, may be unwilling to invest sufficient resources in such projects. (iii) Indivisibilities; economies of scale and the need for pooling of risk may prohibit

effective research for many firms below a critical size and serve to limit competition among the larger firms. (iv) Imperfect markets; the output of many projects will not be traded in perfect markets (i.e., urban transportation, health, educational technology, etc.) which may lead to a divergence between social returns and private incentives, thus inefficiencies in producing or distributing knowledge in these areas results (Slitter, 1966, pp. 223-224).

The arguments against governmental incentive for R&D activities are that it provides windfalls for some firms for doing what they normally do in a competitive economy. It distorts the choices of the marketplace and produces un-neutralities in the allocation of resources [1] (Surrey, 1971). The incentives tend towards permanence, thus leading to waste and inefficiencies (Wolfman, 1965).

Governmental activities to stimulate R&D activities take a variety of forms. These include patent protection, favorable regulatory and anti-trust policies, direct government spending via agencies and government sponsored laboratories, technical information services, support of education and training of scientists, engineers, and technicians, and favorable provisions in the tax code. Among all the incentives, the focus in this study is solely on the effect of tax incentives on investment in research and development.

Paquet (1971) examined the case for R&D tax incentives in Canada, which has had a variety of assistance programs and tax incentives for R&D since 1960. Paquet estimates that the Canadian government paid for 40% to 55% of the scientific activities of industry in the 1960s and also observes that "one cannot find much evidence that these programs and policies have been seriously evaluated" (Paquet, 1971, p. 431). Kaplan (1976, Chapter 1, p. 76) writes "It is also impressive how little is known about the effects of any

of the tax incentives or direct government subsidies on R&D and innovative activities. Writer after writer indicated our lack of knowledge in this area."

Thus this study is undertaken as a pilot study of IRDIA and its effect on R&D and innovative activities. The next section presents the sample selection, the data collection, and the results of the survey. A final section provides a summary, conclusions and limitations.

Scope of the Study and Research Methodology:

The objectives of IRDIA were perceived to be the following (Statistics Canada, 1969):[2]

- (1) To encourage an increased growth rate in industrial R&D by inducing Canadian corporations to undertake new scientific research problems and to expand existing ones.
- (2) To encourage the establishment of independent research laboratories, research associations and technical consulting services whose purpose was to provide specialized support services for industrial research and development.
- (3) To encourage greater cooperation between industry and universities on research related to industrial problems.
- (4) To increase technological innovation contributing to the economy as a whole.

In this study the attempt is to gauge the extent to which the above objectives were achieved. This study is intended to be only a preliminary empirical evaluation of tax incentives for R&D under the IRDIA program. No attempt has been made to seek or to use all available information, nor has any sophisticated statistical analysis been undertaken. The primary reasons for the above decision are as follow:

- (i) There were a number of grant pro-

grams (and tax incentives) in effect at the time of IRDIA, making it difficult even with statistical techniques to isolate their influences. (ii) It was considered that a general overview is necessary to identify possible areas for further study.

The basic research methodology that is used is a questionnaire survey. The questionnaire was developed using the same questions as AICPA (1973, PP. 80-114) study of accounting for R&D Expenditures. The decision to use the same questions was based on the fact that these were well-tested questions and the AICPA study was also concerned with behavioral aspects of R&D expenditures.

However, to provide further assurance that the questionnaire was understandable and of manageable length, it was pilot-tested using a group of 30 randomly selected firms. The questionnaire was also reviewed by the appropriate personnel at the commerce ministry. The thrust of the questionnaire was to determine the following:

- (a) the patterns of expenditures for R&D by class of industries and technologies;
- (b) the impact on the length of the R&D projects due to tax incentives;
- (c) the extent of successful development of technologies and the commercial exploitation thereof.

The above determinations will help in evaluating the achievement of objectives one and four of IRDIA described above.

A list of companies that had utilized the tax incentive programs was obtained from the Commerce Ministry of Canada. The list constituted approximately 180 firms with high research concentration. Of the 180 firms, a random sample of 60 firms was selected for the study.

Before the survey was conducted the questionnaire was again pilot-tested using another group of 30 companies, selected at random from the remaining 120 firms. The questionnaires were

mailed to the 60 selected firms during the summer of 1986. The replies were to be returned in a self-addressed envelope. To maintain anonymity, no identifying information was requested. Out of the 60 selected firms, 51 firms returned the questionnaire, representing a return of 85 percent. However, eight returned questionnaires were unusable, resulting in 43 usable returns. The next section presents the empirical (survey) results.

RESULTS AND ANALYSIS

Overview

The most important result of the survey is that during IRDIA years the R&D projects undertaken were of longer duration (overall) compared to that of post-IRDIA years (please see Table 3). The implication of this result is that IRDIA incentives for R&D did induce companies to undertake projects requiring longer periods to complete. To that extent IRDIA achieved one of its objectives. However, one could argue that the post-IRDIA R&D undertaken by firms probably concentrated on the commercial aspects (final products) of the innovations developed during the IRDIA period.

The second important result of the survey is that the younger firms (0-5 years) had the highest success rate (80%) in producing commercially successful products in the high technology field. The more mature companies (6 years and older) enjoyed a relatively higher success rate in the medium and the low technology field. Furthermore, there is no difference between the consumer goods and the capital goods companies in their overall commercial success rate (please see Table 2). It is the nature of technology and the age of the firms that had bearing on the success rate. However, diversified companies did have a higher overall rate of success than the other two groups (see Table 2).

Detailed Results

Of the firms that utilized (tax) incentive programs during IRDIA, approximately 42% identified themselves as capital goods manufacturers, 35% as consumer goods manufacturers, and the rest (23%) were diversified companies. The majority of the firms (approximately 59%) that took advantage of the program were older firms which had been in existence twenty years or more. The rest of the 41% were distributed as follows: approximately 11% had been in existence for five years or less; 17% between six and ten years; and 13% between eleven and twenty years. From the analysis of the questionnaire, it is inferred that the majority of the firms which participated in the IRDIA program were older firms specializing in the capital goods sector of the economy.

The first objective of the IRDIA program was to provide incentives for the companies to engage in long-term R&D in order to develop new technologies. It appears that during the IRDIA period (1966-76) approximately 54% of the R&D budget of the firms (surveyed) was devoted to development of new technologies and 46% to improvement of existing products and technology (please see Table 1). However, the situation reversed after the incentive period expired. Between 1976 and 1982, only 41% of the budget was devoted to developing new technologies and 59% of the R&D budget was devoted to improving current technology and products. To that extent, tax incentives to induce firms to undertake more risky R&D projects, i.e., development of new technology, was effective, and based on the survey data, IRDIA appears to have succeeded in this objective.[3]

The data were further analyzed to determine if the overall pattern of R&D budget allocation was repeated among the categories of firms. This was done to determine whether there were dif-

ferences or similarities and what the implications might be. To provide an answer to this inquiry, questions one and four were cross-classified and analyzed and the tabulation is presented in Table 1. The results show consumer goods firms during the IRDIA period (1966-76) allocated approximately 57% of their R&D budgets to improve existing technology and 43% to develop new technology. During the post-IRDIA period (1977-82), the allocations show 68% to R&D and 32% to new technology. Thus a higher percent of an R&D budget (43% versus 32%) was allocated to develop new technologies during the IRDIA period.

The capital goods firms during the IRDIA period allocated 35% of the R&D budget to improve existing technology and 65% to develop new technology. The allocations for the post-IRDIA period were 46% and 54%, respectively. Again, a higher percent of the R&D (65% versus 54%) was allocated to develop new technologies during the IRDIA period.

The diversified firms allocated approximately 37% of the R&D budget to improve existing technology and 43% to develop new technology during the IRDIA years. During the post-IRDIA period, the allocations were 48% and 52%, respectively. It appears that the allocations are reversed between these two periods. An inference that can be drawn is that the IRDIA incentives (i.e., tax incentives) did not influence the diversified firms to allocate higher R&D resources to develop new technologies. However, all firms taken as a group did allocate higher percent of R&D to develop new technologies during the IRDIA years.

The study also tried to ascertain the success of R&D expenditures in terms of identifiable end products and commercial success, the objective being to provide a (rough) probability estimate of achieving the R&D project objective and probability of commercial

Table 1

R&D Expenditures (percentage) during IRDIA and Post-IRDIA Periods
by Type of Firm (Industry)
(Cross Classification of Questions #1 and #4)

Consumer Goods	To improve existing technologies	57%	68%
	To develop new technologies	43%	32%
Capital Goods	To improve existing technologies	35%	46%
	To develop new technologies	65%	54%
Diversified (other than the above categories)	To improve existing technologies	57%	48%
	To develop new technologies	43%	52%
All firms	To improve existing technologies	46%	59%
	To develop new technologies	54%	41%

Table 2

R&D Technological and Commercial Success
(Cross Classification of Questions #1 and #7)

Industry	Technology	R&D Technological Success Relative Percent		Commercial Success (%) given Techno- logical Success		Overall Commercial Success (%)
Consumer Goods	High	12	(15)*	36	(7)*	55.47
	Medium	39	(15)	52	(13)	
	Low	49	(14)	63	(11)	
Capital Goods	High	46	(18)*	49	(14)	55.80
	Medium	38	(18)	61	(14)	
	Low	16	(18)	63	(11)	
Diversi- fied	High	35	(10)*	55	(8)*	64.75
	Medium	40	(10)	60	(9)	

*Numbers in parentheses () are number of respondents to Question #7
on the questionnaire.

success for the 1967-82 period. The tabulated data is presented in Table 2.

These data indicate that consumer goods firms experienced a 12% success rate in achieving the objectives of R&D in high technology goods. Out of these 12%, only 36% achieved commercial success. For the medium technology goods, the technological success rate was 39% and the corresponding commercial success rate was 52%. For the low technology goods, the technical success rate was 49% and the corresponding commercial success rate was 63%.

The firms engaged in capital goods industries experienced a 46% rate in high technology R&D in achieving their goals, and almost 49% of these successful projects achieved commercial success. The success rate for medium technology R&D projects was 38%, cut the commercial success rate was almost 62% (61.43%). The corresponding statistics for low technology R&D were 16% and 63%. The general conclusion is that the success rate of achieving the

objectives of R&D projects is a decreasing function from high to low technology. However, commercial success rate is an increasing function.

This brings us to the most important objective of IRDIA: Did incentives for R&D give rise to technologically advanced projects? A basic assumption that is being made is that a technologically advanced project on the average requires longer time to complete. The statistics of the length of the projects are presented in Table 3. The statistics are divided into three categories, i.e., the younger, the most (mode) and the older projects. The rationale for the categorization is that project duration times follow a beta distribution (Moder and Phillips, 1970).

From Table 3 we find that the average length of the older projects during the IRDIA period was 5.82 years compared to 3.53 years during the post-IRDIA years. This is a definite indication that during the IRDIA period technologically advanced projects re

Table 3
Statistics of R&D Projects' Longevity
during and after the IRDIA Period

	During IRDIA		After IRDIA	
	μ_1 Mean (years)	σ_1 Standard Deviation	μ_2 Mean (years)	σ_2 Standard Deviation
Youngest Projects	0.91	0.2	0.926	0.187
Most Projects	2.15	0.66	2.175	0.85
Oldest-Projects	5.82	1.45	3.53	1.19
All Projects (assuming distribution)	2.56	1.53	2.193	0.81

quired longer completion times.[4] Hence IRDIA did achieve its most important objective. However, there were no differences in complete times of most (i.e., typical) projects and the short-lived (younger) projects. Thus the tax incentives during the IRDIA period produced the desired overall effect.

Summary and Conclusions

The objective of this study was to study empirically the impact of tax credit for research and development activities in private firms. The Industrial Research and Development Incentives Act (IRDIA) of Canada was selected for the study because of its generous provisions and the act was perceived to provide general encouragement for R&D. A questionnaire was the instrument used to collect data for the study.

The first important finding of the study is that during the IRDIA period, long-term R&D projects were undertaken that were of longer duration than those of the post-IRDIA period. This finding may imply that firms were willing to invest in long-term research due to availability of tax incentives for R&D. If it can be assumed that, in general, long-term research leads to development of high technology and thus contributing to general economic well-being, then IRDIA did achieve one of the perceived objectives.

A second finding is that the younger firms (0-5 yrs) enjoyed the highest success rate in the field of high technology, both in terms of technological success and commercial success.

The third finding--that there is no significant difference in the success rate (commercial) among the various classifications (i.e., consumer goods companies, capital goods companies, and diversified companies)--may imply that is not necessary to differentiate various sectors of the economy for R&D tax credit.

The fourth, and most important, result of the study is that IRDIA was quite successful in diverting R&D funds to developing new technologies compared to the post-IRDIA period, except for the diversified companies (Table 1). However, the overall results indicate that a larger portion (54%) of R&D was devoted to developing new technologies during the IRDIA period compared to that of the post-IRDIA period. To that extent, IRDIA contributed to the technological innovations, which was one of its perceived objectives. But the situation exactly reversed after the IRDIA period. The implication of this reversal is that if the point of the tax credit is to promote R&D, what is needed is steady support that companies can count on for their long-term planning (Brown, 1984). However, it could be fine-tuned in terms of shifting funds within the overall R&D budget, as seen from Table 1, and also promote the spending. In a previous study (Department of Industry, Trade & Commerce, 1981, p. 14), it was reported that IRDIA did promote increased R&D spending.

In conclusion, the most important empirical result of the study is that governmental incentives to promote research and development activities of private enterprises is effective and produces results in the intended and desired direction.

Limitation of the Study

The limitation of the present study is that it is based on a questionnaire survey and limited data, with the accompanying shortcomings. Furthermore, there were a number of grant programs (and tax incentives) in effect at the time of IRDIA, making it difficult even with statistical techniques to isolate their separate influences. Also, firms did not provide the data on their asset size, thus limiting the analysis further. Because of the confidentiality provisions of the Act, access to company files was not possible. As a result, the study is only aggregate in nature.

Footnotes

1. This would happen, tautologically, since that is what the incentives are supposed to do.
2. For an excellent exposition on the R&D Tax Environment in Canada, see McFetridge and Warda (1983), Chapter 3.
3. One could argue that the reversal in the allocation of R&D budget during the post IRDIA period was to be expected. Because the technologies that were developed during the IRDIA period needed to be perfected commercially, thus fell into the category of existing technology. In other words, the classification changed with time, whereas the projects did not. On the other hand, it can be argued the tax incentive program would have completely failed if there were no differences in allocation of R&D budget during the IRDIA and post-IRDIA periods.
4. Using the data presented in Table 3, one can test the hypothesis ($\bar{\mu}_1 = \bar{\mu}_2$) for each class of projects and for all projects. Using group "t" statistics (Huntsberger, 1970, p. 216), older projects have statistically significant different lives; other categories are not significant.

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