The Commercialization of Academic Research: Subproject on University Spin-off Companies

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1. INTRODUCTION

Current economic theory views technological innovation as necessary for the creation of sustained economic growth, with technological change enabling growth through increased productivity, improved allocation of resources, and dynamic generation of change industries. Industry Canada (IC) seeks to promote technological diffusion and innovation and to gain a deeper understanding of the sources of innovation and growth in the Canadian economy. Within this context and of particular interest is the commercialization of academic research - the transitional route of technology from university laboratory to the marketplace. Transfer mechanisms include the sale or licensing of patents or inventions, the application of contracted research, and the use of consultants. The focus of this study, however, is the creation of the university spin-off company and its concomitant economic benefits.

The Industrial Research Assistance Program (IRAP) of the National Research Council of Canada (NRC) has had a long and notable history of promoting technological acquisition, capability, development, exploitation, and innovation in Canada. Through its advisory, collaborative, and financial assistance to Canadian firms, IRAP seeks to fulfil its mandate to enhance technological capability. Like its Industry Canada counterpart, IRAP is interested in exploring the economic benefits of university technology transfer activities, particularly the university spin-off company.

IRAP, in the course of its provision of technical assistance to Canadian firms, has collected data on a number of firms which originated as spin-off companies from Canadian universities. In addition, IRAP is aware of academic and public agency studies of such companies. Inasmuch as direct surveys of university spin-offs are not currently possible, the above-cited information sources may well serve as the only empirical input to the study of the commercialization of academic research and the associated economic benefits of the creation of university spin-off companies. Nonetheless, an exacting study of the economic benefits of university spin-off companies, as identified in these academic and public agency investigations, is a complex issue. It must be recognized that a rigorous economic analysis requires data to identify such variables as university spin-off company sales, net profit after tax, number of employees, firm size, firm maturity, firm ownership, capital investment, geographical region, access to financing, time frame, payoff period, exports, government funding, managerial ability, etc.

The primary focus of this project is the amalgamation of data sources and the synthesis of a comprehensive database. A "test" of the degree to which such a compilation of data is appropriate to a rigorous economic analysis of the benefits of university spin-off companies is also a part of this project.

This study examines the economic activity, history, and impact of a subsample of 124 university spin-off companies. These are companies which have received or continue to receive IRAP financial support for their technological activities. Many of these firms have grown to such prominence that their names are familiar to Canadians; other firms have not fared so well. This study compiles IRAP data and, based on that information, explores the degree and level of the aggregate and sectoral economic benefits of university spin-offs.

IRAP specifies four distinct classifications of university spin-off companies:

1) "Professor, Inc." - a university researcher who works as a consultant, not a manufacturer.

2) Technology transfer to an existing company (i.e., licensing or joint ventures)

3) A new company set up by university researchers to commercialize their innovation

4) A student forms his/her own company

In this review of 124 university spin-off companies, we look at the third category for which IRAP is aware of at least 200 of a larger universe of 250 such companies. The latter figure is based upon a Science Council report that counted 150 such third-category university spin-offs; IRAP is aware of an additional 100 created since publication of that report, ergo the tally of 250. Of the 200 companies known to IRAP, not all have received IRAP assistance and hence IRAP has no comprehensive financial information for them. This has resulted in the reduction of the sample to 124 companies. This subsample is believed to be indicative of the larger population.

METHODOLOGY

2.1 Data Sourcing

It is understood that any rigorous economic analysis of university spin-off companies requires reliable time series information, including firms' sales, net profit after tax, year

of incorporation, research and development (R & D) expenditures, government support, employment, R & D staff, etc. For the most part, the analysis in this study is based on data and academic studies provided by IRAP. IRAP-supplied data consists of paper files - company, interview, personal, summary collection, and project - in addition to the electronic files of IRAPNet, Dataease, and Biolisting; the nature of these files and the data contained within are described below. No new surveys of firms were conducted for this study.

Obtaining reliable or usable data points from the IRAP-supplied files is a challenge, the most salient problem being that the majority of IRAP-assisted company information is neither machine readable nor readily accessible. The vast bulk of information can be found in hundreds of IRAP project files dating back to the inception of IRAP. Many of the files have been archived or destroyed. Moreover, as IRAP has evolved, so have its programs and its methodology for project designation; IRAP files have grown accordingly. Traditionally, IRAP-supported projects are assigned an element, typically an alphanumeric designation, that is used to code the type of the project, its funding, and the nature of the collaboration. A complete enumeration of these codes includes elements H, L, M, PILP (Program for Industry/Laboratory Projects), P, R, R1, R2, RDA (Research Development & Adaptation), TE (Technology Enhancement), D1, D2, and D3, the latter eight designations representing more recent IRAP support. In addition to these project files, there also exist IRAP company files, benefit interview files, invoice files, ITA (Industrial Technology Advisor) files, regional office files, summary collection files, and university files.

IRAPNet represents a significant advancement in IRAP's move to online data sourcing. IRAPNet provides tombstone information on IRAP-supported projects, company statistics (name, address, contact, number of employees, etc.) and other information pertinent to IRAP's work. IRAPNet provides no time series information on its clients and many of its records do not go back before 1989. It is essentially an online directory and a project funding record system.

Dataease is a spreadsheet used by the Technology Assessment and National Coordination (TANC) group of IRAP. This database lists companies' financial information as gleaned from their IRAP application forms (generally, these applications ask for financial and employment information for the previous year, the current year, and the following year; previous-year information is the most reliable with all other information being company projections). However, the Dataease database provides information on few of the 124 university spin-off companies.

Biolisting is a Lotus-based spreadsheet that tracks IRAP-supported biotechnology companies in much the same manner as does

Dataease, the difference being that Biolisting is exclusive to the biotechnology sector. While it, too, makes use of IRAP application form information, it also incorporates some commercial information.

A preliminary "test" of the quality of these data sources was performed using two randomly-picked IRAP-supported companies as a trial sample. It was determined that information provided from IRAP alone would not be enough to facilitate a complete economic analysis, so other data sources were searched for information availability, applicability, cost, quality, and reliability.

Not surprisingly, given confidentiality restrictions, there are few publicly-available databases that provide thorough economically-useful descriptions of non-publicly-traded firms. Given the incomplete nature of IRAP files, two commercial databases, namely, those of BOSS and Compact Disclosure, were reviewed to enhance the data quality. Moreover, while records maintained by Statistics Canada and Revenue Canada may contain more exhaustive information, such a rigorous undertaking is beyond the scope and resources of this project; however, a time/cost estimate of this work has been requested from Statistics Canada and is discussed later in this report. This investigation is based entirely on the two commercial databases plus the confidential records kept by IRAP.

The Business Opportunities Sourcing System (**BOSS**) is an on-line database (with hardcopy directories available) containing information about Canadian manufacturers of goods and services who have chosen to provide information and list themselves with BOSS. BOSS currently lists over 26000 establishments and 77 of the 124 university spin-off companies were found in its online version. BOSS lists a variety of discrete and static information; of interest to this study are the following variables: sales, exports, staff, incorporation date, and years in business. However, all figures are given in ranges and may not necessarily be available: there are many "blanks". Time series data is made available only through the use of hardcopies of older BOSS directories and an involved search of these is beyond the scope and resources of this study.

Compact Disclosure is based on Micromedia's Cancorp database and includes more than 8500 Canadian public, private, and crown companies. The essential difference between Compact Disclosure and its Cancorp parent is the currency of the information: Cancorp is updated constantly while Compact Disclosure is available on CD-ROM and may lag its parent by a few months. Nonetheless, Compact Disclosure is exceedingly useful in its provision of up to seven years of financial data - including income and balance sheets, annual reports, capital stock changes, and the like - the caveat being that their corporate records were

available to the public for inclusion in the database. Small firms are very unlikely to be found on the Compact Disclosure database. Fifteen of the 124 firms were found on Compact Disclosure, two of which were listed under their parent corporations, reflecting the reality of the mergers and acquisitions that have taken place since these university spin-offs were first formed. Of course, being on the public exchange need not imply success as many of these companies may be in a developmental phase, financial trouble, and/or supported by public funding.

Of the commercial and IRAP electronic databases (BOSS, Compact Disclosure, Dataease, Biolisting, and IRAPNet), 620 searches were made, yielding 268 files which were input into an Excel spreadsheet. The search of the IRAP paper files was more problematic in light of the fact that the exact tally of IRAP paper files is unknown; for the sample of 124 companies, the IRAP files could number well in to the hundreds, even when ignoring multiple project files, ITA files, regional office files, university files, and duplication. Irrespective of the 185 files which were directly provided by IRAP, 825 searches were made of paper IRAP interview, M, P, R, RDA, TE, and summary collection files, yielding an additional 105 files which were incorporated into the spreadsheet. A further 1240 searches were made of the ten hardcopy directories (listed in the Directory bibliography) and all relevant information was likewise added to the spreadsheet. Despite the enormity of the data search and collection, several "holes" were evident in the final spreadsheet and many of the companies had to be excluded from the economic analysis due to lack of reliable information and, in some cases, any information at all. One company was found not to meet with the definition of a university spin-off as used in this study, and it was dropped from the list. A discussion of the final university spin-off subsample is found in the Economic Analysis section of this paper.

2.2 Academic Studies

Included among the seven IRAP/IC-provided studies are the Martin [16] paper, the Doutriaux [8,9,10,11] papers, and the Science Council [1,5,12] papers listed in the bibliography of this report. These papers did not address the economic impact of university spin-off companies in any quantifiable manner that could be standardized or pooled with data from this investigation. Regardless, these papers and other material are discussed in the literature review later in this report.

Given this apparent lack of accessible "hard" information, Informetrica searched a number of sources for additional academic or commercial work. At the present time, it would appear that

there is no authoritative source on the economic benefits of university spin-off companies in Canada. However, there do exist three pieces of work, namely, those of Brenda Hutchinson [14], Frank Longo [15], and D. Roland Thomas [18] that provide statistical, methodological, and information-sourcing insight into how one could best approach such an investigation. While the first two works are currently unattainable, they were reviewed in a prior Informetrica report by C.E. Hughes & P.M. Jacobson [13] and they are discussed at length in the following literature review. The Thomas paper [18] has been procured and is likewise discussed.

3. LITERATURE REVIEW

While they may provide an interesting inspection of the social and psychological aspects of successful and unsuccessful university spin-off companies, the Doutriaux papers [8,9,10,11] do not offer any rigorous quantifiable insight into the economic benefits of spin-off creation that can be standardized or pooled with our collected data. Of note, however, is the fact that Professor Doutriaux accomplished his work by surveying the characteristics of successful university spin-off entrepreneurs and their parent universities; unfortunately, however, his database was not made available for the purposes of this study. Doutriaux's correlation analysis of his collected data examines the effects of such factors as university policy, university culture, and regional environment on spin-off success. Quite clearly, he advocates that the academic entrepreneur is the key factor in the early success of the spin-off firm and, while the papers do yield some interesting aggregate statistics about his subsample of spin-off firms, without access to his microdata, they remain inapplicable to our study at hand.

The Martin paper [16] describes a survey of university-industry collaborations, discussing issues, problems, and benefits at great length. The paper is exclusively qualitative, but it does offer some engaging and informative detailed case studies of university-industry collaborations.

The Science Council of Canada papers [1,5,12] provide an interesting perspective on the transfer of technology and university spin-off companies, but the papers do not address a quantifiable economic benefit of such activity. The papers comment on the marketing and time management demands of spin-offs and they remark upon how technology transfer offices should be run, but they offer qualitative information only. Certainly, these works represent worthwhile studies of the technology transfer mechanism and how it can best be managed, but they, too, provide no usable data to be standardized, compared, or pooled with data collected for this study.

Related to our study are the works of Brenda Hutchinson [14], Frank Longo [15], and D. Roland Thomas [18]. While these papers do not restrict themselves to university spin-off companies, but choose instead to look at the broad spectrum of IRAP-assisted companies, they remain useful to this study because they describe a statistical methodology to investigate and compare economic benefits. They also offer useful criticism and insight into the problems associated with using a statistically non-random sample population, as is the case with our 124 university spin-off companies.

Hughes & Jacobson [13] write that the now-unavailable Longo Statistics Canada econometric firm-level microdata-based study [15] concluded that the sample of IRAP companies was distinctly different from the general population of firms [as approximated by the average of all Census of Manufacturers (administered by the Manufacturing and Primary Industries Division of Statistics Canada) firms in the same broad industry and class] when compared with attributes other than IRAP: there existed a selection bias. They assert that Longo's statistical comparisons between IRAP firms and average Census firms were inappropriate because IRAP firms were not representative of a random sample of the firm population but, rather, were unique and non-random in their preoccupation with R & D and sophistication. This point is well taken when considering the objectives of this study. Economic analysis must make use of aggregate industrial data to gauge the success of the university spin-off sample, despite the fact that this sample is known to be non-random. This is a statistical drawback resulting from limiting the current study to those university spin-offs that have received IRAP support.

A study by Thomas [18] is available and is notable for its use of the "IRAP multiplier", the ratio of sales to IRAP funding, as the best indicator of economic performance. This is akin to TANC's "C3" ranking of project success, discussed below. Using 104 IRAP-funded companies/projects from a 1974-1977 review period as the information set (it is not known whether or not university spin-off companies were included in Thomas' sample), Thomas discovered that large companies (greater than 1000 employees) exhibited significantly higher IRAP multipliers than did small companies (less than 200 employees), and that for Canadian-owned (or controlled) companies, the medium-sized (200 to 999 employees) ones out-performed both their small and large counterparts. Thomas further asserted that relative performance was not a function of industry type (taking into account company size) when using the four large industry sectors of Electrical/Electronic Products (plus machinery), Chemical Products, Food and Beverages, and Forestry and Mining Products. Presumably, these general characteristics would hold true for university spin-off companies, but confirmation would require further investigation. Much to his credit, Thomas was quick to

point out that the presence of some selection bias could cloud results and that a larger sample was required.

Another significant, but unavailable, work, that of Brenda Hutchinson [14], attempted to incorporate the suggestions of the Thomas study. As Jacobson & Hughes note, this document largely reports on the preparation and construction of a file from the Revenue Canada T2T4 (firm-level records maintained by Statistics Canada based on the corporate tax T2 form and the T4 record of payroll deduction information made available from Revenue Canada) database to be used in an IRAP versus non-IRAP firm comparison. Jacobson & Hughes characterize the Hutchinson work as suffering from the shortcomings of an inadequate matching between IRAP and non-IRAP firms, flaws in classification and coding, and poorly constructed production functions for use in regression analysis. To the best of our knowledge, no work has been done with this database since 1987. Nonetheless, this work serves as a useful example of the labour that is required for the construction and cross-linking of databases; an analogous endeavour is discussed later in this report with regard to Informetrica's recommendations for follow-up work and a Statistics Canada cost/time estimate of securing information on the 124 university spin-off companies.

Although the Hutchinson, Longo, and Thomas papers all reviewed IRAP-funded companies, the underlying data are not available and no identification of spin-off status was made. For the purpose of this study, these works are useful only for their methodological approaches.

At the time of writing, two potentially-related studies were unavailable for review: a California case study of spin-offs [6] and a report by Desmond McG Blair [2]. An academic study by Professor H. Clifton Young of the University of Alberta is a work in progress and its stated intent to examine management and marketing in the setting of university spin-off companies may not be directly relevant to this study.

4. ECONOMIC ANALYSIS

4.1 Descriptive Variables

Working under the direction of the University Research Policy (URP) group of Industry Canada and with the supervision of the Director of IRAP-TANC, five company variables were sought to enable economic analysis: sales, number of employees, company R & D expenditure, year of incorporation, and net profit after tax. University spin-off companies were further coded and classified

within four broad industrial categories: electrical/electronics (E), life sciences (L), materials (M), and software (S). Additional information was sought, but not found in numbers great enough to allow a more rigorous economic analysis; for example, existing data sources have not provided much information with regard to exports and a number of "holes" are found in the spreadsheet due to the incomplete nature of the available data sources.

With regard to the university spin-off company data, the rates of formation, profitability, and failure were examined. These variables were so defined by TANC to be incidence of incorporation, positive net income after tax, and zero company sales, respectively. As an aside, it is interesting to note that TANC currently rates projects with four levels of "success":

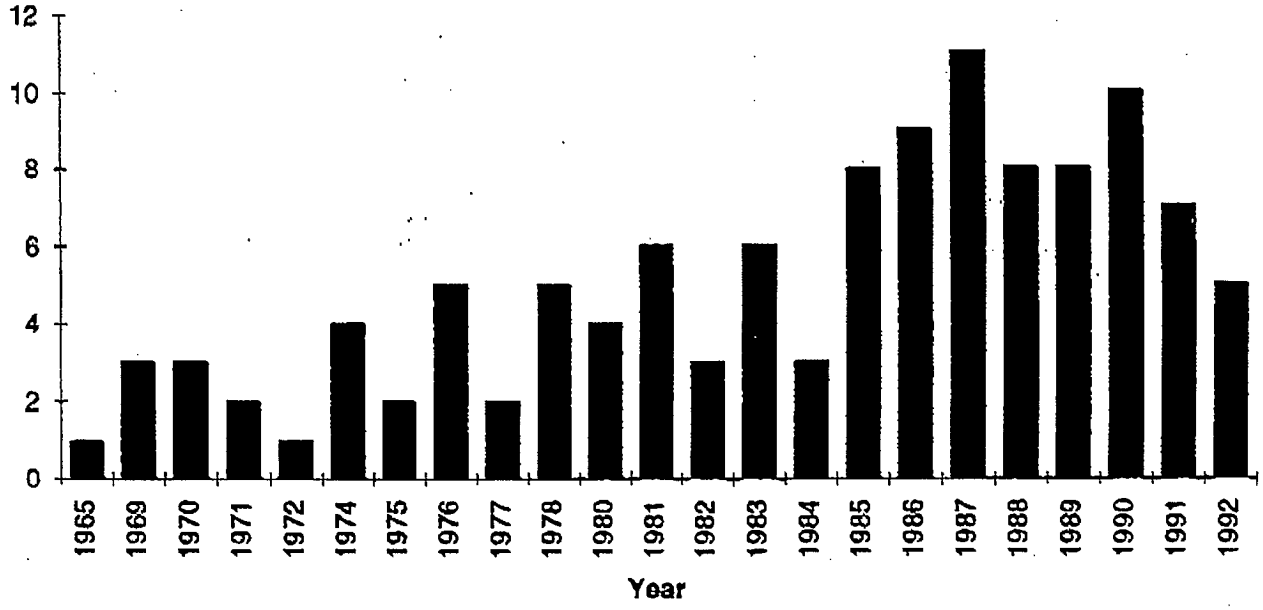
C0 = "failed" (no sales)
C1 = "no results yet, too early"
C2 = "some dollar benefits"
C3 = "significant" = "sales 30x IRAP investment in first 3-4 years of sales"

While the TANC definitions do provide a qualitative perspective, they are rather vague for the purposes of economic analysis. Informetrica also attempted to analyze the economic activity and benefits of the 124 university spin-off companies vis-a-vis major economy-wide aggregates. In this manner, comprehensive employment data can be used to estimate the contribution of specific firms to overall economic activity. Similarly, sales or gross output would be indicative of economic benefit, as would labour productivity approximated in the form of sales-to-employee ratios. This analysis and its outcome is discussed below.

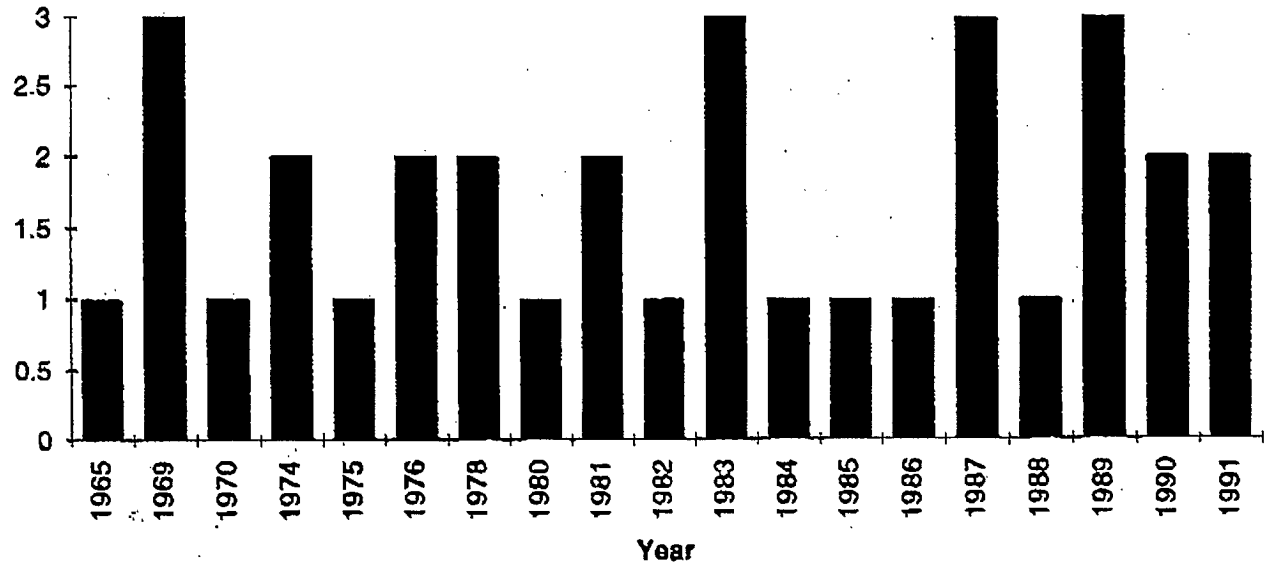
4.2 Sample Reduction

The 124 university spin-off subsample consisted of 36 "E", 58 "L", 5 "M", and 25 "S" companies before it was ultimately reduced to 26 companies for further economic analysis. Of the original 124 university spin-off companies, 117 reported incorporation dates. One company had to be dropped from the list because it was later discovered not to have been a university spin-off (as defined for this study by "category three" listed above); this reduced the number of known-to-be-incorporated firms to 116. The incidence of incorporation for these 116 university spin-off companies, including their 33 type "E", 57 type "L", and 21 type "S" elements, in addition to the overall net change in the number of Canadian manufacturing establishments, is provided in the graphs that follow. The latter graph represents the entry of new establishments less the exit of existing ones.

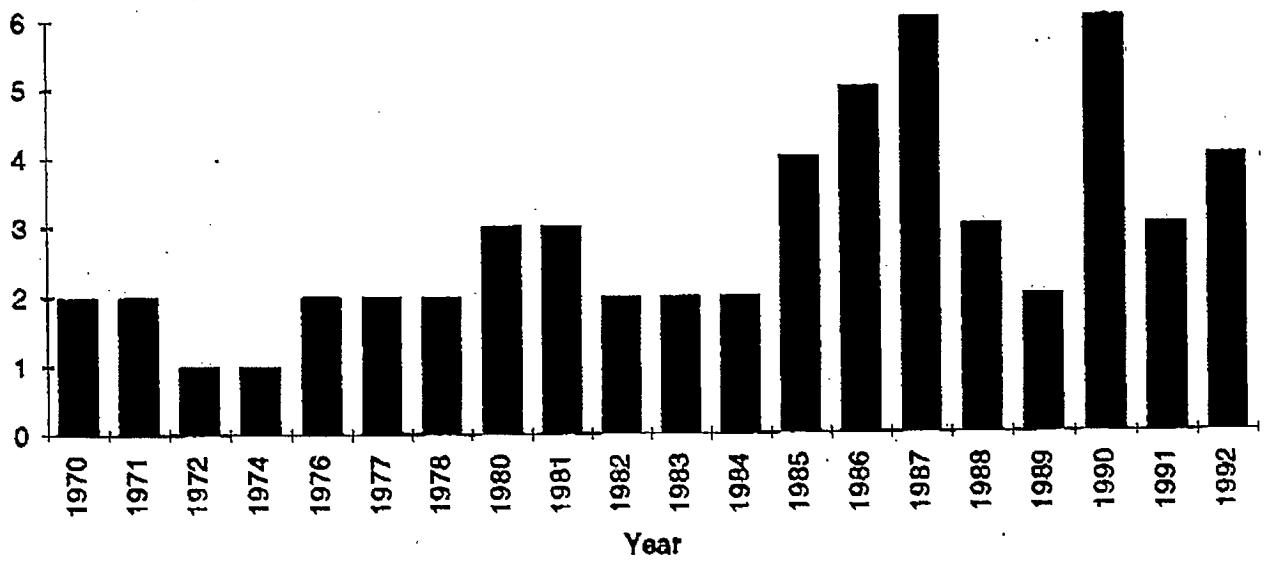
Incidence of Incorporation for 116 University Spin-Off Companies



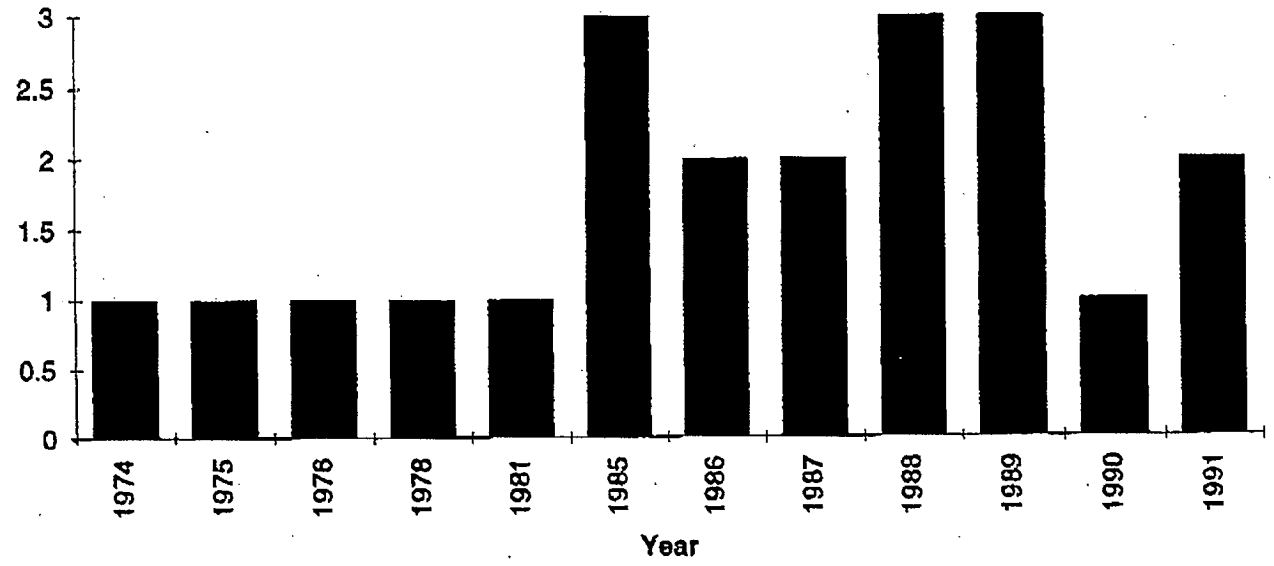
Incidence of Incorporation for 33 "E" Type University Spin-Off Companies



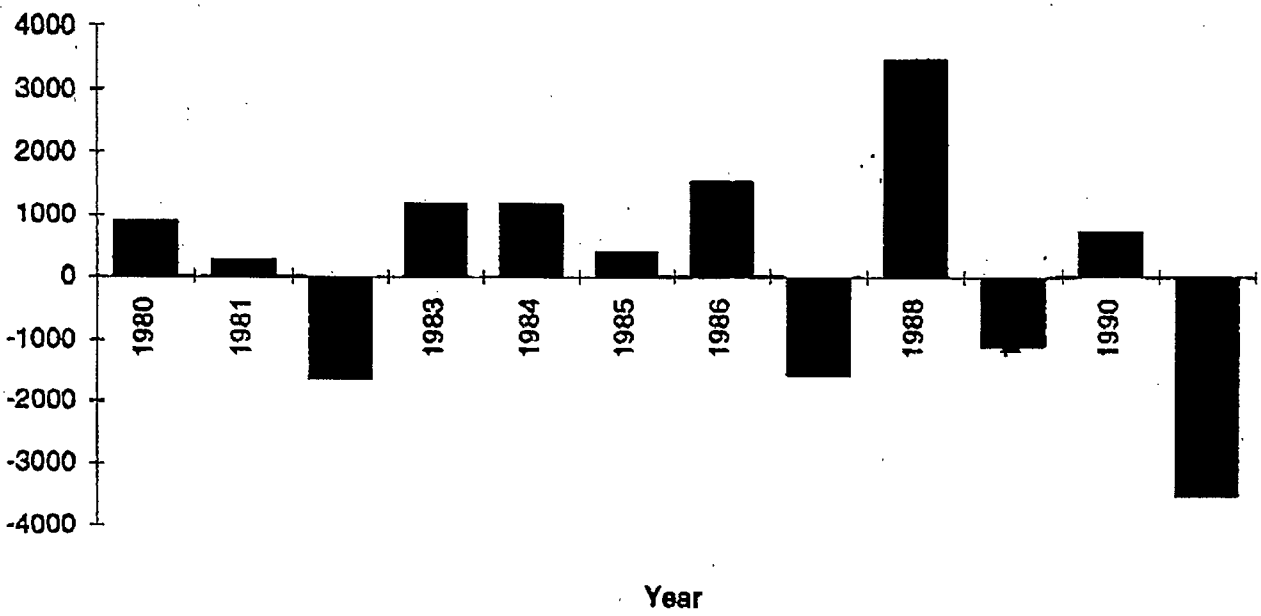
Incidence of Incorporation for 57 "L" Type University Spin-Off Companies



Incidence of Incorporation for 21 "S" Type University Spin-Off Companies



Net Change in Number of Manufacturing Establishments



Source: Statistics Canada

Of the reduced sample of 123 university spin-off companies, many of the remaining companies were eliminated because of insufficient or poor-quality data. Essentially, the problem was that there were few companies for which reliable time-series data was available. The majority of the university spin-offs did not have enough data points to allow any economic analysis; of those that did, much of their data was based on company projections and, as such, was considered unreliable. The most reliable information was that garnered from company annual reports or sourcebooks, with the "second choice" for reliable information being company financial information as gathered from the "previous year" section of IRAP application forms.

A first sweep of the spreadsheet revealed 69 university spin-off companies with two or more years of partial information on the four variables of sales, net profit after tax, number of employees, and company R & D expenditure. A second sweep of the spreadsheet found 53 companies with 3 or more years of partial information on these same four variables. Ultimately, only 26 university spin-off companies (consisting of 12 "E",12 "L", 0 "M", and 2 "S" companies) were found with at least four reliable pairwise data points on two or three of the "core" variables of

sales, net profit after tax, and number of employees. Inclusion of company R & D in the data matrix would have caused the usable sample size to dwindle even further; there was little doubt that the university spin-offs were R & D performers. Unfortunately, the majority of university spin-off company data was inadmissible because it was based on company projection; a proposal for the procurement of reliable information is discussed later in this report. It is recognized that the subsample of 26 university spin-off companies may not be representative of the larger whole.

4.3 Data Trends

Of the 123 university spin-off companies, 18 were known to have been the participants in mergers and acquisitions, 19 were known to be publicly-traded companies, 5 were known to have closed (with one of these companies having been subsequently bought by a public agency), and 2 were identified by ITAs to be "no longer functioning", but not bankrupt or closed. The Office of the Superintendent of Bankruptcy provided an insolvency probe (1978 to 1994/04/08) of the university spin-off companies which revealed that one of the spin-offs was bankrupt and another had a petition pending; the former company was also one of the five companies known to be closed. The Corporations Directorate of Industry Canada was asked to check if the university spin-off companies were federally incorporated and, if so, whether or not they had filed an annual report; that query had not received a response at the time of this writing.

Using a very broad definition of failure (zero company sales), there are few failures to be found among the 123 spin-off companies for which data is available. The issue of profitability is more problematic. While sales rise and fall with the business cycle, they seldom go to zero for the spin-off sample, unlike net profit after tax, which is often negative. The incorporation graphs shown earlier in this report indicate that the sample is skewed toward post-1985-incorporated companies, yet that the overall rate of incorporation is rising, despite a general economy-wide decline in the establishment of new firms. In essence, our analysis has captured the aggregate effects of startup lags, growth to maturity, and economic hardship. Interestingly, using TANC definitions, many university spin-off companies may be considered to be successful, yet not profitable.

For the reduced subsample of 26 university spin-off companies, the table on the following page represents a synopsis of their economic performance:

Company No.	Company Type	Overall Net Profit After Tax	Sales History	Employment Growth
1	E	- 0	↑	↑
2	E	> 0*	↑*	static*
3	E	~ 0	↑	↑*
4	E	< 0	↑ and ↓	↑ and ↓*
5	E	< 0*	↑	↑
6	E	< 0*	↑*	↑*
7	E	> 0*	↑*	↑*
8	E	inconclusive*	↑*	↑*
9	E	< 0	↑	↑*
10	E	> 0	↑	↑ and ↓
11	E	< 0	↑ and ↓	↑ and ↓
12	E	< 0*	↑ and ↓*	↑
13	L	< 0	↑	↑
14	L	< 0*	↑	↑
15	L	inconclusive*	↑*	↑*
16	L	<< 0*	↑	↑
17	L	> 0*	↑↑	↑
18	L	- 0	↑	↑*
19	L	< 0	↑ and ↓*	↑ and ↓
20	L	< 0	↑ and ↓	↑ and ↓
21	L	<< 0*	↑	↑↑
22	L	inconclusive	↑	static
23	L	> 0*	↑ and ↓*	↑ and ↓
24	L	> 0*	↑*	↑↑
25	S	~ 0	↑	↑
26	S	> 0	↑ and ↓	↑ and ↓*

↑ steady increase over time
↑↑ strong increase over time
↑ and ↓ increase and decrease over cycle
<<0 much less than zero

*does not include post-1990 data

As the preceding table indicates, the majority of the 26 university spin-offs have experienced consistent growth in sales and employment over time. Time trends in net profit after tax are less conclusive.

4.4 Sectoral Trends

A look at aggregated sales, net profit after tax, company R & D expenditures, and number of employees is provided in the following table:

Co. Type	FY	Sales ($000's)	Net Profit after Tax ($000's)	Co. R&D ($000's)	# Employees
E	74	42 (1)		24.3 (1)	46 (2)
E	75	135 (1)		26.7 (1)	10 (1)
E	76	3065 (2)		102.6 (2)	71 (2)
E	77	5028.7 (6)	32.6 (2)	224.6 (3)	107 (5)
E	78	2389.8 (5)	146.5 (3)	361 (3)	83 (3)
E	79	2199.7 (4)	102.1 (3)		15 (2)
E	80	8180.5 (5)	225.8 (3)	1192.3 (3)	203 (5)
E	81	14442.7 (6)	1228.1 (5)	1316.5 (4)	226 (4)
E	82	25021.1 (7)	1802.8 (5)	782.4 (3)	259 (4)
E	83	39096.1 (8)	2218.7 (4)	3776.3 (4)	480 (6)
E	84	21311.2 (5)	1227.1 (4)	2788.8 (2)	437 (5)
E	85	27250.2 (5)	-556.3 (3)	4066.9 (2)	561 (4)
E	86	19032.2 (5)	-3074.8 (5)	485.7 (3)	196 (5)
E	87	4511.9 (6)	248 (6)	554 (2)	27 (3)
E	88	4537.9 (6)	-966.2 (6)	803 (4)	270 (7)
E	89	6941.3 (6)	64.5 (6)	1063.5 (4)	66 (4)
E	90	8716.4 (4)	-547.7 (4)	2322.9 (3)	81 (4)
E	91	3024.6 (3)	-165.5 (2)	491 (1)	32 (2)
E	92	3426 (3)	-116.5 (3)	996.4 (3)	57 (3)
L	71	307 (1)		32.9 (1)	18 (1)
L	72	408.3 (1)		39.5 (1)	22 (1)
L	74	644 (1)		181 (1)	24 (1)
L	75	15 (1)			
L	77			287.6 (1)	8 (1)
L	78	51.8 (1)		267.5 (1)	12 (1)
L	79	213.5 (2)		299.4 (1)	15 (1)
L	80	122.2 (2)	-1.5 (1)	6.6 (1)	7 (1)
L	81	417.7 (3)	-220.2 (3)	27.3 (1)	13 (2)
L	82	3730.4 (5)	-537.3 (5)	50.6 (2)	48 (4)
L	83	5839.6 (6)	1137.4 (7)	200 (1)	117 (6)
L	84	4677.8 (4)	577 (4)	400 (2)	63 (3)
L	85	2832.5 (5)	-1169 (4)	2700 (2)	115 (5)
L	86	1489 (4)	-5417.1 (5)	5400 (1)	160 (6)
L	87	2305.9 (4)	-7936.1 (5)	5248.6 (2)	90 (3)
L	88	16709.3 (7)	-11120.2 (6)	28.4 (1)	363 (9)
L	89	104553.2 (6)	-11871.7 (5)	3812.4 (4)	234 (4)
L	90	12269.8 (6)	-16072.1 (5)	11756.4 (2)	220 (6)
L	91	47153.7 (8)	-9414 (5)	3365 (1)	105 (3)
L	92	41900 (3)		731 (1)	573 (6)
L	93				368 (2)
S	74	8 (1)	-14.6 (1)		
S	75	40 (1)	18.3 (1)		
S	76	49.2 (1)	15.8 (1)		
S	77	143.8 (1)	97.2 (1)		
S	78	86.1 (1)	38.2 (1)		
S	79	76.7 (1)	1.5 (1)		
S	80	122 (1)	24.4 (1)		
S	81	152.5 (1)	61.5 (1)		
S	82	332.4 (1)	223 (1)		
S	83	477.6 (1)	25.3 (1)		
S	84	615 (1)	62.5 (1)		
S	85	951.8 (1)	87.7 (1)		
S	86	1833.4 (1)	-307.4 (1)		22 (1)
S	87	0 (1)	0 (1)		4 (1)
S	88	386.9 (1)	90.6 (1)		
S	89	98.5 (1)	-56.5 (1)	29.4 (1)	4 (1)
S	90	231 (1)	14.2 (1)	134 (1)	3 (1)
S	91	6428.2 (2)	-180.6 (2)	1016.8 (1)	80 (2)
() = No. of Companies Reporting					

The limited sample and the quality of the data do not merit a useful economic analysis. Industrial microdata is not available for comparisons of university spin-offs on a firm-by-firm basis. Similarly, the aggregate categories of "E", "L", "M", and "S" are too broad to allow for comparisons on an aggregate industrial basis. On a qualitative level, however, the data do indicate that these university spin-off firms have made contributions to the Canadian economy as measured by their growth in sales and employment. While the history of prolonged negative after-tax profit for "L" type companies may be indicative of significant startup periods and lengthy growth rates to maturity, generalizations about the "E"and "S" company types are less forthcoming. Broad-category aggregation may have clouded the results.

5. SUMMARY & RECOMMENDATIONS

IRAP assistance, through its promotion of technological acquisition, development, and innovation, can be characterized as designed to lower the cost of acquiring information while increasing the efficiency of the effective use of technology. Such assistance also provides a valuable pool of technological knowledge and capability from which firms may garner increased returns on assets, increased sales, lower input costs, and so on. In this manner, and as discussed in the literature review, IRAP-assisted companies are part of a non-random sample which skews our examination of university spin-off companies because we are limited in this investigation to study those companies that receive or continue to receive IRAP assistance. Furthermore, given such an incomplete sample, policy decisions dealing with university spin-offs are impossible to make, especially when one considers the fact that the use and promotion of technology is a long-term, time-lagged, and strategic economic process, further complicated by the aspects of follow-on funding by other agencies, incrementality (i.e., if the company would have performed its research without government support, then government support is a subsidy), and attribution (i.e., do smart companies come to government agencies or do government agencies make them smarter?) - these are all additional issues, not within the scope of this study. Finally, if innovation is to be viewed as part of an overall economic strategy that hopes to fulfil some goal (such as reduced unemployment, regional development, increased exports, etc.), then our limited economic analysis of the benefits of university spin-off companies can only be considered a prelude to a more complete assessment.

In addition to the variables examined in this study, of further interest would be the investigation of the relationship

between university spin-off company performance and industry, firm size, firm maturity, firm ownership, capital investment, geographical region, access to financing, time frame, payoff period, exports, government funding, and managerial ability. Econometric studies and proposals to date have largely focused on the composite effects of such variables, making for a too general, but easier-to-assess enquiry. We would propose to increase the sample of university spin-off firms, extending the sample to include those that did not receive IRAP assistance and utilizing exhaustive time-series data to account for changes in the business cycle and variations in economic performance.

A major recommendation for IRAP is to expand their own files, coding and documenting them in machine-readable form for the variables enumerated above and further linking these files to Statistics Canada data. Such a linkage would permit an investigation of the extent to which technological innovation is a growth pole for economic activity and how that innovation need best translate itself from university to marketplace. Whether or not other transfer mechanisms, such as licensing, reliance on foreign R & D, trickle-down technology, reverse engineering, etc., are more suitable is an issue which would require further study.

While an investigation into the advisability of using federal funds to assist the commercialization of academic research is beyond the scope of this paper, the lack of any authoritative study on the economic benefits of such activity belies the need for such an undertaking. The standard government intervention support paradigm asserts that private firms are unable to capture the rents made available from their technological innovations despite the availability of patents, licensing agreements, and other forms of protection. Leakage is inevitable and a negative externality is borne by the research firm when the benefits of new technology are made available to free-riding competitive firms. Accordingly, a firm will base its investment decisions only on that portion of benefits that it expects to get back; in an interventionist environment, governments' role is to compensate for this leakage. Indeed, an examination of the economic consequences of current legislation with respect to patent law and intellectual property rights would provide another perspective on the advisability of using federal resources to assist universities in their efforts to generate spin-off companies. In addition, the question arises as to what extent government support aids the firm beyond the obvious injection of capital. Possible intangible attributes of such agencies as IRAP and IC include up-to-date information on technologies currently in use, expertise in the management and transfer of technology, and technical insight or know-how as to what technologies have commercial and/or technical merit.

A more meaningful comparison of university spin-off companies and their industrial counterparts is not possible without a more thorough classification of industries and the examination and utilization of a large and reliable database. The ideal comparison is one made between two matched firms, university spin-off and other, with near, or identical inputs (investment, labour, capital) and production function (the use of those inputs). Firm-specific attributes such as entrepreneurial ability, business acumen, leadership skills, management and labour skills, the existence of a branch plant mentality, etc., are all firm-specific attributes that need to be accounted for within the larger environment of market forces, availability of venture capital or financing, and the prevailing economic climate. While management skill is not readily measurable, other variables may be assigned and constructed to serve as proxies for otherwise untenable information.

In short, the recommended approach to evaluating the effectiveness of using federal funds to assist universities in their efforts to generate spin-off companies would be to compare these companies with their best-matched non-funded counterparts, making use of a large sample period, multi-year time-series analysis, an expanded production function that attempts to proxy such variables as "management effects", etc., and a standardized classification code to enable linkage with existing databases.

In this vein, Statistics Canada was asked to provide a time and cost estimate for the retrieval of more reliable data. The particulars of this discussion are provided in a letter to Industry Canada. Using its financial database (based on the T2T4 tax file), Statistics Canada would provide aggregated data concerning the university spin-off companies and their sales (as proxied by gross revenue), total wage bill, and net profit after tax. Lacking in this information set would be the number of employees, exports, year of incorporation, as well as R & D data. This missing information would most likely be found within two other Statistics Canada databases, the employment and R & D databases. Establishing linkages between three such databases (financial, employment, and R & D) complicates the data search considerably and would involve significant time and expense. Nonetheless, such a venture is the necessary and requisite first step in an economic analysis that would allow the formation of a perspective on the advisability of using federal funds to assist university spin-off companies.

In summation, this study collected, compared, pooled, and standardized data, as provided by IRAP and academic sources, on a sample of university spin-off companies. Academic, financial, and industrial data were investigated to determine the economic benefits of these companies: the outcome revealed that the quality and quantity of the data were insufficient to facilitate a rigorous economic analysis. Statistical approaches used in

similar investigations were discussed in a literature review and an analytical framework to determine the economic benefits and costs of university spin-off companies was outlined.

The key finding of this study is the following. If a definitive and exhaustive study of the economic benefits of university spin-off companies, and the advisability of using federal funds to assist them, is to be carried out, a broader data set is required. While the data consolidation carried out for this report enhances the database for Canadian university spin-off companies, there still exists the need for the collection of more reliable and complete information. Much of the information cannot be gleaned from existing databases and may be best sought from firm-level microdata surveys that assign variables to proxy such factors as "management effects", etc. Other data searches are required to find commercial, industrial, and financial information dealing with profits, sales, exports, employees, etc. This information may be most likely found in Statistics Canada databases, but that source may not provide a complete set. In short, without the acquisition of more exhaustive and reliable data, it is not possible to perform a rigorous analysis of the economic benefits of university spin-off companies, the commercialization of academic research, or the advisability of using federal funds to assist such firms.

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