The Effect of R&D Incentives on Stock Returns

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ABSTRACT

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The Federal Government of Canada has, since the early 1960's, attempted to encourage corporations in Canada to invest funds in research and development through a series of tax incentives. While previous studies have investigated the effectiveness of these incentives, this thesis will explore what impact they have had on the market value of firms that undertake R&D. To perform the analysis, event studies are carried out for eleven event dates upon which significant changes to Canadian R&D tax incentive laws were made. Subsequently, a relationship between the abnormal returns earned by firms and their specific characteristics is formulated. Finally, based on the results presented in the study, recommendations for future research and development incentive programs are made.

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Dedications

I'd like to dedicate the thesis·

To Dad for furnishing me with an interest in finance.

To Mum for luring me into a world of learning.

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Introduction

In mid-December of 1994, the research and development tax policies of the federal government of Canada came under intense scrutiny, as reports that "Canada's largest banks, ..., [were] quietly claiming hundreds of millions of dollars in tax credits under a ... program designed to encourage leading-edge science"[1] made headlines across the nation. The public's outrage was simple: why were the country's banks, coming off one of their most profitable years ever, getting richer off a government that could ill-afford lost revenue at a time of crushing public debt? And worse, why did it appear that the tax credits had done little, if anything, to encourage the type of research that assumably the government was trying to encourage via their tax incentives.

The problem was not a new one for the federal government. Indeed, since the early 1960's, Ottawa has attempted to encourage corporations in Canada to invest funds in research and development through a series of tax incentives. The reason for such tax policies is clear. The government is striving not for a transfer of its wealth to the private-sector, but for benefits for all of Canadian society through an increased pace of research and development. In order for Canada to remain competitive in an international market place, it must strive to be as technologically modern as possible, hence the need for research and development incentives.

Over the last fifteen years, however, a number of studies have been undertaken to assess how effective government incentive programs have been at actually encouraging

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[1]The Globe and Mail, December 15, 1994, A-1.

research and development.[2] For the most part, these studies have shown incentive programs to be only mildly successful at best. This paper will address a separate, but related question. If the tax incentives provided by the Canadian government have historically had little success at encouraging new R&D spending, have they nonetheless had the effect of increasing the value of firms that carry out R&D? That is, this thesis will explore whether the various tax incentives put forth by the federal government of Canada since 1975 have had any effect on the market valuation of firms that undertake R&D. In order to test for a valuation change, event studies will be carried out for twelve event dates upon which changes to Canadian R&D tax incentive laws were made.

The thesis opens with a presentation of the objectives of the research to be carried out, and an indication of why the research is significant. This is followed by a review of the literature relevant to research and development tax incentives, and an examination of the general theory of event studies. The paper then considers the options that are available to the federal government for promoting research and development, and outlines the history of incentives for research and development expenditures in Canada between 1964 and 1992. An overview of the research methodology used in this study is then carried out. The results of the event studies are then presented and analysed. Analysis consists of both an interpretation of changes in market valuation of portfolios as a result of changes in incentive programs, and in an examination of the relationship between the abnormal returns earned by the firms in the study

[2] See, for instance, Dwyer (1989), Mansfield and Switzer (1985), and McFetridge and Warda (1983).

Research Question and Objectives

The thesis proposes to answer the question: "*Have changes in taxation incentives for research and development, as implemented by the Federal Government of Canada since 1975, had any effect on the market valuation of firms that undertake research and development?*"

Although many studies have been performed to examine the effectiveness of various R&D tax incentives, none in Canada have examined their effect on the market value of firms. This study is therefore unique, and will shed light on the actual economic value of the federal government tax policy changes. Furthermore, by *investigating the relationship between a firm's abnormal returns, and its specific characteristics*, a clear picture of who wins and who loses from various government regulation changes will emerge. The study should clearly have implications for future government tax policies both here and abroad.

Literature Review

The Benefits of R&D Tax Incentives to Firms

The literature shows two basic methods for calculating the savings due to R&D tax incentives. The first method is to simply calculate the after tax cost of a dollar spent on R&D before the tax change, then to calculate the after tax cost of a dollar spent on R&D after the tax change, the benefit (or loss) being the difference between the two costs. The problem with such an approach is that it implies that in the case of additional allowances and accelerated depreciation, higher corporate tax rates are beneficial to the companies paying them. Clearly, this is misleading as higher tax rates simply make R&D spending relatively more attractive than other projects, but do not make R&D projects more attractive in and of themselves.

For this reason, McFetridge and Warda have developed a more appropriate measure of the impact of a tax concession on R&D expenditures, which they call the beta index. The beta index is defined as that "ratio of the present value of project-related before tax income to the present value of the project-related costs at which an R&D project becomes profitable for the firm that undertakes it."[3] As such, it is a type of hurdle rate that an R&D investment must earn in order for the firm to accept it.

In a world with no taxes, the beta value for a firm would be 1. The net present value of a projects inflows would have to be at least equal to the net present value of its outflows. In a world with a tax rate $t = 0.5$, and where R&D expenditures could be deducted immediately, \$1 of revenue would be taxed to leave the firm with \$0.5, and \$1

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[3]McFetridge and Warda (1983) p 17.

of expenses would only have an after tax cost of $0.50 to the firm. Consequently, the beta in such a world would remain 1. If R&D expenses were not deductible at all, $1 of before tax revenues would be taxed to leave the firm with $0.5. However, $1 of expenses would continue to have an after tax cost of $1. Consequently, a firm would need a present value of before tax revenues of at least $2 in order to undertake the project. That is, the firm would need revenues with a before tax present value of two dollars for every one dollar that the project costs. Using the terminology developed by McFetridge and Warda, the firm would face a beta of 2. Now consider a world where t=50%, R&D expenses are fully deductible, and the government pays firms a taxable credit of 20% of their R&D expenditures. Let us assume that the firm has a before tax outflow of $1 for an R&D project. It will receive $0.60 from the government ($0.50 for the tax deduction plus $0.20 for the tax credit less the $0.10 tax paid on the credit) so that the net after tax cost of the investment is $0.40. In order to undertake the project, it must anticipate at least $0.40 in after tax revenues. Since revenues are taxed at 50%, the firm must anticipate $0.80 in before tax revenues. Its beta ratio, the ratio of before tax revenues to before tax expenses that a project must meet before it becomes profitable, is therefore 0.8.

The beta approach for measuring tax incentives is particularly well suited for ranking tax incentives i) within a particular country over time, and ii) across different nations. In fact, Canada's beta index was calculated by McFetridge and Warda for the period 1952-1982, as was a comparison of betas across 20 different countries. An extract of their work is reproduced in Table 1 and Table 2.[4]

[4]Both tables assume an inflation rate of 10% and discount rate of 15% to calculate the betas

Table 1: Canada' s Beta Index Over Time

Period	Beta
1952-1960	1.010
1961-1966	0.922
1967-1976	0.753
1978-1982	0.767
1983-1994[5]	0.800

Table 2: Comparison of International Betas, 1981

Country	Beta
Canada (10% credit, manufacturing)	0.79
Germany (10% credit)	1.06
Japan	0.95
United States	0.90
United Kingdom	1.00

As indicated by the tables, Canada has not only had a trend of mostly increasingly generous R&D programs, but their R&D incentives rank highly when compared to other competing countries. McFetridge and Warda, however, are quick to emphasize that the beta measure shown above does not include the incentives provided by governments by way of subsidies and contracts. However, they go on to show that even after incorporating these incentives into the beta calculation, that Canada retains it

[5]This beta figure was calculated as per the earlier example and assumes only that the minimum tax credit of 20% is available

number one ranking relative to its main competitors.[6]

After concluding that Canada's R&D incentive system is sufficiently generous relative to the incentive system of other nations, McFetridge and Warda proceed by considering the absolute adequacy of the incentive system. To do so, they propose that an incentive system is adequate when it makes it profitable for a firm to proceed with all projects that have a societal benefit equal to the company's cost.[7]

In order to help with the analysis, assume that on average, for each dollar of benefit that a firm receives from an R&D project, that society also benefits by one dollar. In other words, there exists an external benefit to society from the information provided by the project that the firm can not keep to itself, so the social benefit-cost ratio is twice that of the firm's benefit cost ratio. Clearly, a beta index of 0.5 would set an equilibrium such that the firm will undertake all projects that have a societal benefit cost ratio of 1 (0.5*2).

Working with the data from Table 1, we see that the beta in Canada from 1983-1992 was 0.800. This implies that the Federal Government believes that the social benefit-cost ratio is 1.25 (1.0/0.8) times the private benefit cost ratio. Is this in line with other estimates of the social to private benefit ratio of R&D expenditures? According to estimates made by Edwin Mansfield et al., it is not.[8] In an estimate based on major U.S. R&D projects undertaken in the 1960's, they estimate that said ratio is between 1.77 and

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[6]McFetridge and Warda(1983) p 83

[7]McFetridge and Warda (1983) p. 84

[8]Mansfield, Rapoport, Romeo, Villani, and Husic (1977)

2.50. Care should be taken when reading these figures as they were based exclusively on large R&D undertakings. Smaller projects may not have such a large societal benefit.

If Mansfield's externality estimate of 1.77 is accepted as valid, then all nation should theoretically pursue a beta index of 0.56 (1/1.77). This assumes that all projects other than R&D have a social to private benefit ratio of exactly 1. However, this perfect market assumption may be too bold to make. If a social to private benefit ratio of 1.1 is assumed, then a beta index of 0.62 would be acceptable.[9]

It seems at this point that Canada's R&D incentives, although not necessarily generous enough in absolute terms, are very generous when compared to those of other countries. Two interesting questions at this point are: 1) How well are these incentives working? and 2) How well are incentives in other countries working?

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[9]McFetridge and Warda (1983) p.86.

The Success of Canada's and Other Countries' R&D Incentive Programs

One way to measure the success of Canada's incentive programs is to compare the amount of money Canadian businesses spend on R&D versus the amount of money spent by other comparable nations' businesses. Table 3 shows that when Canada is compared to other countries, they lag significantly behind in R&D expenditures. In fact, Canada's business expenditures on research and development (BERD) to GDP ratio is last compared to the countries above despite the fact that its beta index is ranked #1.[10]

Table 3: BERD to GDP (%)

Country	1989	1990	1991
Japan	2.1	2.2	2.2
United States	2.0	1.9	1.9
Germany	2.1	1.9	1.8
United Kingdom	1.5	1.5	1.4
Canada	0.7	0.8	0.8

Some researchers have attempted to directly measure the effect that certain tax incentives have had on company R&D expenditures. By and large, research has shown that firms react mildly at best when it comes to increasing R&D in order to better take advantage of tax incentives.[11]

Specifically, Mansfield and Switzer, in their paper "The effects of R&D tax credits and allowances in Canada," perform a detailed analysis in an attempt to measure the

[10]Statistics Canada (1993) no.82-202 p.14

[11]See Mansfield and Switzer (1985), Mansfield (1984), Eisner, Albert, Sullivan (1984), Dwyer (1989)

impacts of both a tax credit introduced on R&D expenditures, and allowance for overexpensing R&D costs. To carry out their analysis, survey results, estimations based on the elasticity of demand for R&D, and econometric results were used.

The survey consisted of either interviewing or requesting principal officials in 55 firms to fill out a questionnaire (or both). The survey results indicated that the investment tax credit resulted in less than a 2% increase in R&D, while the special research allowance led to less than a 1% increase, and that the impact of the incentives remained almost constant over time. Because these results were based on a survey, they are subject to bias both with regard to the formation of the questions on the survey, and with regard to how the respondents answered the questions. However, at least with respect to the second bias, one would expect the respondents to exaggerate the increase in R&D expenditure, as they most certainly are in favor of the incentives available.

Mansfield and Switzer also used R&D's low elasticity of demand to help explain the small reaction to the incentives. By calculating an average reduction of $0.11 for each dollar spent on R&D, and assuming that about one half of the new incentives are useable and that the elasticity of demand for R&D is about 30%, Switzer and Mansfield demonstrate that an 3.0% increase in R&D expenditures could be expected.[12] In total, an estimated increase in R&D expenditures of $50 million resulted compared to government foregone revenues of about $130 million (in 1982).

Finally, based on econometric studies that investigate the relationship between cash

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[12]These estimates (made for a large firm) are based on very rough assumptions. However, as long as the elasticity of demand for R&D is low, and a significant proportion of R&D incentives are unuseable, the estimate remains reasonable

flow and R&D, Mansfield and Switzer show that the increase in R&D attributable to the tax credit would be about 1%.

How do these results compare to studies undertaken in other nations? Larry Dwyer considers the effect of a 150% tax concession on current R&D expenditures that was introduced in Australia in July 1985. To measure the effect, Dwyer calculates the per cent reduction in the Beta Index that resulted from the tax change ruling (about 44%). By multiplying this change by an elasticity of demand for R&D of 30%, Dwyer estimates that R&D expenditures increased in Australia by as much as 13%. However, this estimate seem to exaggerate the true affect. First, as Dwyer admits, not all firms would be able to use the entire concession. If, as Mansfield and Switzer estimate, only about half of the total available incentive is used, then the estimated increase in R&D would fall to 6.5%. Second, the rate of change in R&D expenditures actually dropped after the tax concession was introduced, from 31% between 1982 and 1984, to 12% between 1987 and 1988.[13] Finally, if the effect of the tax concession were as large as estimated by Dwyer, one might expect that the percentage of R&D spent on current costs to total R&D costs would grow. However, this was not the case. In fact, the ratio remained constant between 1984-1990 at 86.2%. Finally, Dwyer compares the estimated increases in R&D expenditures to the government's forgone revenues.[14] Even when using his overly optimistic estimates of the effects of the concession, he finds that increases in R&D expenditures are roughly only 60 to 70% of forgone government revenues.

[13]Dwyer (1985) p 319

[14]Dwyer (1989) p 324

Edwin Mansfield, in "Public Policy Toward Industrial Innovation: An International Study of Direct Tax Incentives for Research and Development," [15] considers the effectiveness of R&D tax incentives in Sweden, Canada, and the United States. His results for Canada, developed with work he did with Switzer, was described earlier. In the United States, he considers the effect of the Economic Recovery Tax Act passed by congress in 1981. The act provided for a 25% tax credit for R&D performed over and above a base period (the firm's previous three year R&D average expenditure). After surveying 110 firms, it was found that R&D expenditures would have been about 0.4%, 1.0%, and 1.2% lower in 1981, 1982, and 1983 respectively had the credit not existed.[16] Further, he subdivided the effect of the credit by industry, and excluding instruments and metals, the effect was not too different from industry to industry. Mansfield also formed a 95% confidence interval for the total tax credit induced increase in R&D expenditures and found that it was between 0.6-1.8 percent for 1983. When translated to actual dollars, this amount becomes $277-638 million, well below the treasury departments foregone revenues of about $1 billion.[17]

Mansfield explains the small effect of the incentive by first noting that not all companies are in a position to use the credit. Further, he demonstrates that such a credit is worth only about $0.06 to a firm considering increasing their R&D expenditures, since

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[15]An article written for the 75[th] Anniversary Colloquium on Productivity and Technology at Harvard Business School, (1984)

[16]Mansfield (1984) p 387

[17]Mansfield (1984) p 388

any one year's increase reduces the benefit available in subsequent years.[18] Furthermore, he claims that an estimated elasticity of demand for R&D of 30% is probably too high, as R&D is usually only one component of many when a new project is being considered.

The survey undertaken also asked respondents to estimate the extent to which R&D expenditures have risen solely as a function of applying a less rigid definition to R&D.[19] His results reveal about a 4% increase in R&D reporting from 1982-1983 for this reason alone. This redefining of R&D expenses is consistent with behaviour reported in both Canada and Sweden where the private industry's redefinition of R&D has resulted in about a 14% increase in reported R&D.[20]

Mansfield also reports on a similar study he performed in Sweden, which attempted to estimate the effects of an R&D tax incentive program developed by the Swedish government. Using a survey method similar to the method he used in Canada and the United States, Mansfield found that the 1981 incentive program, which allowed for an additional expense allowance of 5% of R&D expenditures, plus 30% of the increase over the previous year, led to about a 1% increase in R&D expenditures. A 95% confidence interval for the resulting increase in R&D expenditures in 1981 was found to be 0.4 to 1.6 percent (23 to 98 million Swedish Kroner), or from 13 to 56 percent of the Swedish Government's foregone tax revenues (176 million Kroner).[21]

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[18]Mansfield (1984) p 389

[19]The government tacitly encourages such behaviour as R&D expenses receive favorable treatment compared to other expenses

[20]Mansfield (1984) p 390

[21]Mansfield (1984) p 393.

The work put forth by Switzer, Mansfield, and Dwyer seems to indicate that the tax incentives currently being used by many nations are not effectively increasing private companies R&D investments.[22] This remains true despite the large sums of revenues that the governments are foregoing. It seems at this point that governments have by and large failed in their attempt to stimulate more R&D spending. This leads to an interesting question that this thesis attempts to answer. "If the government programs in Canada have failed to adequately encourage R&D, how then have they affected the economic situation of high tech firms? "

[22]Eisner, Albert, and Sullivan (1985) also support this conclusion

Event Studies: Theory and Application

The first event study was undertaken twenty five years ago by Fama, Fisher, Jensen and Roll mostly in an attempt to justify the continued development of the CRSP data tapes.[23] Since this time, event study analysis has become almost a financial field in and of itself. Through it, a great deal of information has been learned, especially in the field of corporate finance. Perhaps the greatest strength of event studies is the relative ease with which they can be replicated, thus "pass[ing] the test of scientific usefulness."[24]

Event studies are used to determine the effects that new information has on the market value of a given stock or portfolio of stocks. As with most areas of finance, increased knowledge has led to a modification of event studies, in an attempt to make their ability to detect excess returns both more accurate and more powerful. How successful these modifications have been, and whether the increased costs and difficulties associated with them warrant their use has been the subject of various papers in the financial field.

Perhaps the most renowned study was a two part analysis undertaken by Brown and Warner.[25] Before an understanding of their work becomes possible, a basic understanding of event study methodology is needed.[26]

In an event study, an attempt to measure abnormal returns earned by a portfolio

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[23]Fama (1992) p.1599.

[24]Fama (1992) p.1600.

[25]Brown and Warner (1980, 1985)

[26]To avoid redundancy, what follows is a descriptive explanation of an event study In the methodology section that follows later in the paper, a mathematical formulation of the model is given.

of firms is made. In the most basic OLS event study analysis, a return generating process following the single factor market model is used to predict market returns in the event window, the period of time over which the abnormal returns are being tested. The abnormal returns for each day in the window are then calculated as the difference between the actual return earned and the predicted return. The abnormal returns for each day in the window are then standardized and averaged to result in an average standardized abnormal return (ASAR). If the experimenter wishes to examine the average standardized cumulative abnormal return (ASCAR), he can subsequently sum the ASAR's of a given period. Finally, the experimenter can calculate Z-statistics for both the ASAR and the ASCAR in order to test for significance.

This model of the event study makes several assumptions about the data that are unlikely to hold true. First, the daily stock returns being examined do not generally follow a normal distribution. Rather, the data tends to be leptokurtotic (fat tailed), and skewed to the right. These results are true both for the returns themselves as well as for the excess returns.[27] Furthermore, non-synchronous trading may result in biased and inconsistent estimates of the single factor market model parameters. Specifically, firms that are actively traded have upward biased betas while firms that are thinly traded have downward biased betas.[28] Other concerns about event studies include the effect of using longer event windows in cases where the exact date of the event is unknown and the estimation of the variance of the mean excess returns where there exists autocorrelation

[27] Brown and Warner (1985) p 10

[28] Brown and Warner (1985) p.16

and increased variances around the event date.

Brown and Warner decided to investigate what effects these considerations would have on the effectiveness of event studies. To do so, they performed two hundred and fifty simulated event studies incorporating the problems discussed in the previous paragraph into their simulations. The first problem, the non-normality of data, was found to have no marked impact on event study methodologies. Even when as little as five stocks are included in the event study, the probability of type one error remains appropriate.[29]

In their study, they also found that procedures other than the OLS model for estimating the market model do not have any obvious benefit over the OLS model, even for thinly or actively traded stocks. When the exact date of the event is unknown, Brown and Warner found that the test statistic continues to be well specified, but that the power of the test declines.[30]

Finally, Brown and Warner found that the choice of estimator for the variance to be used in the hypothesis testing may be of some concern where there is high autocorrelation in the time series of mean daily excess returns. However, tests which assumed cross sectional dependence of error terms were shown to have significantly less power, and only mildly improved the specification of the excess returns.[31]

Since Brown and Warner's study, other researchers have mostly confirmed their

[29]Brown and Warner (1985) p.25

[30]Brown and Warner (1985) p.14

[31]Brown and Warner (1985) p.26.

work. Specifically, a simulation examining monthly returns was undertaken by Malatesta who investigates whether there exist benefits to using a generalized least squares approach compared to other simpler procedures.[32] His results show that a GLS model is not any more powerful than an ordinary least squares regression method, and that it may even be less powerful.[33] However, Malatesta is careful to warn that stock returns for firms in a given industry are more likely to have highly cross correlated stock returns than are firms randomly picked for simulation purposes, and that the GLS method *may* produce some benefit when used under such circumstances.

This concern is rather important because many event studies involve stocks that either come from the same industry, or at least share various important common characteristic(s). A study extending the tests performed by Malatesta was performed by McDonald in an attempt to discover to what degree the above problem would affect event study results.[34] In his study, McDonald examines both daily and monthly return data of firms that actually are undergoing an event (a stock split).[35] He then compares the results obtained from performing an event study using ordinary least squares (OLS), estimated generalized least squares (EGLS), and iterated generalized least squares (IGLS). His results confirm the studies performed by both Brown and Warner, and Malatesta. Although McDonald's test is applied to an actual event (where the cross correlation of stock returns is expected to be

[32]Malatesta (1986)

[33]Malatesta (1986) p.38

[34]McDonald (1987)

[35]In his study, McDonald also examined simulated event studies. This part of his study also confirmed the results of Brown and Warner and Malatesta.

significant), he concludes that the differences in power of the various methods to identify abnormal returns is statistically insignificant.[36] In concluding, McDonald states "although systems methods have various characteristics that are amenable to event study applications, the promise of these methods is not supported by a variety of empirical tests," and that "the simple OLS market model is sufficient."[37]

The works described above should not imply that most of the work on event studies has involved simulations for the purpose of testing whether or not event studies are useful. In fact, this is far from the truth. Event studies have been, and continue to be used to provide information on topics ranging from mergers and acquisitions, to dividend policy, to weekend effects, to government regulations.

It is this last topic that is of the most concern in this paper. But regulation changes as a focus for event studies carry with them a particular set of problems. Different studies by various authors suggest in more detail some of the problems, and some potential solutions to these problems of which those undertaking a regulatory event study should be aware.

Traditionally, researchers have examined the effects of regulation by examining accounting rather than financial data.[38] However, several problems result from using accounting data to measure the effects of regulation. For instance, in order to use accounting data, a researcher must estimate how long a transition period between the

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[36]McDonald (1987) p.502.

[37]McDonald (1987) p.503.

[38]Binder (1985) p.167.

regulation change, and its effects on financial statements will be. Furthermore, the effects of the regulation change are hard to separate from changes the company would have incurred regardless of the ruling. For these reasons, Schwert has suggested using financial data in lieu of accounting data to measure the effects of regulation.[39]

One evident way to use financial data is to perform an event study. By comparing the reaction of a certain subgroup of companies to a market that is otherwise not affected by the regulation change, a researcher can make a timely, specific examination of the effects of the regulation change. Unfortunately, event studies as they apply to regulation changes have certain characteristics that make them harder to perform than regular event study.[40] Perhaps the most important difference between a regulatory event study and most other event studies is that the event date itself is usually hard to pinpoint. Because regulation changes generally pass through several stages before being passed into law, uncertainty exists regarding what date should be considered the event date. For instance, should the event date be the day that the legislative body first proposes the rule change, the day that the media first publishes reports that a rule change is being considered, or the day that the proposal is formally passed into law. To further complicate the issue, regulation changes are generally anticipated by the market. Because regulation changes are seldom made in isolation (i.e. lobby groups and politicians often debate the issue before a rule change is adopted) an exact date is even more difficult to specify.

Timing is not the only difficulty associated with this type of event study.

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[39]Schwert (1981)

[40]Binder (1985)

Regulation changes seldom affect all firms identically.[41] In fact, regulation changes can even affect intra-industry firms in opposite ways, depending on each firms' particular characteristics. Because a regulation change may affect one firm one way and another firm in the opposite direction, it is possible that there will be a cancelling effect among the firms being examined. Consequently, the event study may conclude that the event was insignificant when in truth it was not.

Finally, one must be particularly careful when drawing conclusions from regulatory event studies. Consider a situation where a regulation change (for instance, an allowance to more quickly depreciate mining equipment) occurs at the same time that there is a surge in metal prices. An event study could reveal that the regulation change had a significantly positive effect on the value of mining stocks, when in fact the abnormal returns may have been attributable to the rise in price of precious metals. In general, a regulatory event study runs the risk of forming conclusions that in fact are not necessarily correct.

An article examining the usefulness of stock return data for measuring the effects of regulation changes appeared in the Rand Journal of Economics in 1985.[42] Specifically, the author considered twenty major regulation changes since 1887 where the exact announcement dates could not be specified. In the study, the author considered numerous (up to 54) months surrounding the event period. This large event window was then subdivided to test the most important periods within the event window. Monthly and daily

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[41]Binder (1985) p 168

[42]Binder (1985)

event study analyses were performed. Not surprisingly, the author concluded that the event studies were unable to detect the effects of regulation. The reason that the results are not surprising is that the author specifically picked events that were particularly hard to date. That being the case, it is possible that the events did have significant effects on stock returns, but that these effects were not measurable because of the very imprecise dating of the event. The author also emphasizes that some event windows were shown to have significant returns, but no more than would be expected by chance. He therefore cautions experimenters that chance findings are possible when many event windows are examined. He therefore suggests linking the firms excess returns earned to a firm specific variable in order to reduce the likelihood of a Type I error.[43]

Since this study, examinations of the effects of more recent regulation changes have been made. Two important such studies were undertaken to examine the effects of tax reform in the United States. The House of Representatives' forecasted that The Tax Reform Act of 1986 would raise an estimated $84 billion in tax revenues over the first five years.[44] Financial theory would predict that the change in cash flow resulting from this regulation change should be positively correlated with a firm's abnormal returns. By modelling the excess returns earned by a firm as a function of several variables (including among other variables a firm's net capital stock and growth in net capital stock as well as the estimated cash flow effect attributable to the change in tax laws), a test for the significance of the cash flow change attributable to the tax change was performed.

[43]Binder (1985) p.182.

[44]Cutler (1988) p.1108.

Surprisingly, no significant relationship was found between a firms excess returns and this variable. Cutler suggests that "an explanation for the observed reaction may be inefficient pricing of the tax news by the market."[45] However, other explanations exist. Because the tax reform drastically affected almost all corporations, it is possible that the abnormal returns earned by the firms were not particularly abnormal. That is, a regulation change that affects all companies will not result in particularly salient abnormal returns. Furthermore, the independent variables upon which the abnormal returns were regressed were all estimated. The effect on cash flow was found by subtracting each firms actual tax liability in 1985 from what the liability would have been under the new tax laws and multiplying this difference by the ratio of the tax base of the firm to its market value.[46] Such a measure does not take into account the different tax strategies that each firms' tax department is likely to use in order to reduce it tax liability. As such, it may exaggerate the differences in this variable from one firm to another.

The Economic Recovery Tax Act (ERTA) of 1981 was estimated to have induced a $200 to $300 billion dollar capital loss.[47] The purpose of a study undertaken by Downs and Tehranian was to see if an appropriate model could be developed to predict the windfalls in different industries resulting from the tax policy changes. To measure the windfalls, a window from February 18, 1981 to August 14, 1981 was employed. The large window was necessary because several small announcement dates were made rather than

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[45]Cutler (1988) p 1116

[46]Cutler (1988) p.1109.

[47]Downs and Tehranian (1988) p 1118

one defining one. The conclusions from the study were that the model employed accurately predicted the signs of the windfalls. Apart from demonstrating that their model was able to predict the relative performances of different industries, Downs and Tehranian also demonstrated the usefulness of regulatory event studies. Despite the uncertainty associated with the long event window chosen, the event study yielded results consistent with financial theory.

Even more relevant to this thesis than a general regulatory event study is an event study undertaken that examines the financial effects of an R&D tax credit introduced in the United States in 1981.[48] In fact, the study undertook by Berger attempts to address two issues. First, he attempts to measure whether the R&D tax incentive was successful at increasing R&D expenditures. Second, he performs an event study separating his portfolio of stocks into expected winners, and expected losers. The winners are the firms that are expected to be able to use the credit, whereas the losers are the firms that are expected to be unable to use the credit. The rational for labeling the first group as winners is fairly straightforward. If the firm is able to use the R&D tax credit, then its tax liability in subsequent years will reduce, and the firm will benefit. The rational for expecting losses in the second group is somewhat less straightforward. The argument for expected losses from this group is that they will be forced to pay higher prices for R&D inputs (given the greater demand) without receiving the benefits from the tax credit. Contrary to the work of Mansfield described earlier, R&D intensity (the ratio of R&D expenditures to sales) was shown to increase significantly, and the change was attributed to the

[48]Berger (1993)

regulation change. Furthermore, the author found significantly positive abnormal returns for the firms expected to benefit from the regulation change and significantly negative returns for the firms expected to lose.[49]

The implications of this study are quite relevant to the study conducted here. First, this event study yielded significant results despite the uncertainty surrounding the exact date the event occurred.[50] Second, the study revealed that regulation changes to the treatment of R&D expenditures have, in the United States, been shown to create abnormal returns. Finally, the sign of the abnormal returns have been shown to be related to firm specific characteristics.

Clearly, event studies are an integral part of financial research, providing valuable information to those who understand them. Although great care must be taken when interpreting the results of these studies, they have consistently been shown to provide reliable information.

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[49]Berger (1993) p.167.

[50]Berger (1993) p.153.

Research and Development Tax Incentives in Canada

Definition of Terms

The following will define the various types of research and development tax incentives that are currently in use in Canada, or have been used at one point by the Canadian Federal Government.

Immediate Income Tax Deductions

Immediate tax deductions, as their name implies, allow firms to immediately deduct from income their costs incurred that relate to research and development. Though this may be thought of by most as a general accepted accounting procedure (GAAP) when the expensing relates to current expenditures, it clearly is in violation of GAAP when it comes to expensing capital costs. The savings to corporations owing to immediate income tax deductions are as follows:

Net Benefit = Total Benefit Available - Previous Benefit Available

Assume:

Discount Rate (DR) = 15% p.a.

CCA rate = 33%

Marginal Tax Rate is U_c

Benefit = $U_c - U_c*(CCA/(CCA+DR))$

$= 0.3125U_c$

Additional Allowances

Additional allowances permit the overexpensing of research and development expenditures. For instance, if $1 is allowed to be over expensed at the rate of 50%, then the normal deduction of $1 is allowed, plus an additional $0.50. Generally speaking, additional allowances were only claimable for excess research and development expenditures over the average of n preceding years.

Tax Credits

Tax credits permit a refund equal to some percentage of the cost of research and development expenditures. Unless specifically stated otherwise, these credits could only be used against taxes otherwise payable and could not be collected by the company in question. The amount of tax credits received by a firm is deducted from the firms research and development expense to arrive at their net allowable research and development expense. Various rules regarding the carry back and carry forward of credits have existed since the inception of tax credit policies.

Research and Development Grants

Research and development grants are different from tax credits in two respects. First, grants are non taxable. Second, grants can be claimed by companies regardless of their tax liability situation. In the past, grants issued by the federal government were equal to some percentage of capital expenditures plus the same percentage of excess current expenditures over and above the average of a base period.

SRTC

The Scientific Research Tax Credit is discussed in detail later in the paper.

Refundability

Refundability provisions allow for companies that are unable to use the available research and development tax incentives to receive some of the benefits of their unused tax credits. The amount available for refundability depends on the specification of the tax law in each particular year.

Tax Credits and Additional Allowances: A Comparison of Estimated Values

In order to have a detailed estimate of the value to a firm of both tax credits and an allowance for overexpensing research and development, their effects on the values of two typical companies will be examined.

Table 4: Profile of Two Typical Research and Development Companies

	Company N	Company H
Sales	100	100
Research and Development Expense (RD_{exp})	3	10
Research and Development Growth (RD_g)	14% (for 4 years) then 8% thereafter	8%
N.I.A.T.	5	5
Earnings Discount Rate (K)	18%	18%
Earnings Growth (g)	8%	8%
Tax Rate (t_c)	40%	40%

Upon inspection of Table 4, several points should be noted. First, Company N is a normal research and development company (3% research and development to Sales ratio) whereas company H is a high research and development company (10% research and development to Sales ratio). Furthermore, the growth in research and development for Company N is 14% for the first 4 years before settling at 8%, the rate of growth in research and development for Company H. This follows the argument that company H is less likely to increase its research and development expenditures as much as a company that is spending less on research and development (and therefore has more room for growth). Finally, both companies have the same projected earnings at year t=0, and their earnings are discounted at the same discount rate.

Let us consider first the values of the companies, assuming Miller's zero debt valuation model.

$$V_N = \frac{N.I.A.T.}{(K-g)} \tag{1}$$

$$V_N = \frac{5}{(0.18-0.08)}$$

so that $V_N = 50$. Because of the assumptions laid out in Table 1, V_H also equals 50.

Now, let us consider the value to both firms of a 5% credit (cr=5%) on research and development expenditures. The value of the credit in each year is equal to the reduced tax liability that the firm incurs less the reduction in expensable research and development expenditures multiplied by the firm's tax rate.[51] Summed over an infinite horizon, the net present value benefit from the tax credit for a firm whose research and development expenditures are growing at a constant rate is:

$$V_{cr} = \Sigma_{t=1}^{\infty} \frac{((cr*RD_{exp} - cr*RD_{exp}*t_c)*(1+RD_g)^t)}{(1+k)^t} \tag{2}$$

or \$3.24 for Firm H. For Firm N, a similar calculation is made for the constant growth period, and is then discounted back 4 years. This value is added to the present values of

[51]An assumption that the firm can use all of its tax credit available is made here. This assumption is unlikely to hold for all the firms that are in the sample.

each of the individual benefits from years 1 through 4. This totals to an increased value of \$1.17. It should be noted that the tax credit benefits the high research and development firm by 6.48% while it benefits the normal research and development firm by only 2.34%.

The benefits of an allowance for overexpensing research and development expenditures in excess of the average over the previous three years can also be estimated for the two firms. The benefit in each year is equal to:

$$V_{exp}^{t=n} = \gamma * t_c * \Delta_3^{t=n} \tag{3}$$

where:

γ = the ratio of excess expenditures that is allowed as a deduction (assume γ = 50%).

Δ_3= the increase in research and development expenditures over the previous three years.

Summed over an infinite horizon, the net present value benefit from an allowance for overexpensing for a firm whose research and development expenditures are growing at a constant rate is:

$$V_{exp} = \frac{(\gamma * t_c \Delta_3^{t=1})}{(K - RD_g)} \tag{4}$$

or \$3.04 for Firm H. For Firm N, a similar calculation is made for the constant growth period, and is then discounted back 4 years. This value is added to the present values of each of the individual benefits from years 1 through 4. This results in an increased value of \$1.32.

Two key issues should be noted here. First, an increased expense allowance is more beneficial to a normal research and development firm than is a tax credit, whereas high research and development firms would be more likely to prefer a tax credit. Second, quite high annual growths in research and development expenditures are assumed. This assumption was made because the Canadian government introduced these two measures in the late 1970's, when there was high inflation. In order to keep up with real research and development investments, nominal growth in research and development would have to be quite high. However, if the growth in research and development expenditures were reduced for both firms, it would be seen that at lower growth rates, the increased expense allowance would be more valuable for the normal research and development firm than the high research and development firm. Table 5 summarizes the estimated percent valuation changes for both a normal and a high R&D firm caused by i) a 5% tax credit and ii) a 50% overexpensing allowance.

Table 5: Percent Valuation Changes in Normal and High R&D Firms

	5% Tax Credit	Additional Allowance
Normal Firm	2.34	2.64
High Firm	6.48	6.08

History of Research and Development Tax Laws in Canada

The Federal Government of Canada has, since the early 1960's, attempted to encourage R&D expenditures through the use of a series of tax incentives. A detailed description of the tax changes affecting R&D expenses between March 1977 and October 1992, and a summary of the rules in force prior to this period follow.

Prior to 1961, current expenditures on R&D were fully deductible in the year incurred, while capital expenditures were deductible at 33% per year[52]. In 1961, capital expenditures were made fully deductible in the year incurred. From 1962-66, an additional deduction allowance of 50% for both current and capital R&D expenditures in excess of the base year (1961) was permitted. From 1965 to 1975, this additional 50% reduction was discontinued. Rather, firms became eligible for grants under the Industrial Research and Development Act (IRDIA) equal to 25% of capital expenditures and 25% of current expenditures over the previous five year average. This 25% grant was non taxable and was introduced to benefit R&D firms that were incapable of using the extra expense allowance that previously existed. IRDIA was repealed in 1975 as part of a government restraint policy.

On March 31st, 1977, a tax credit equal to 5% of both current and capital expenditures on scientific research and development was introduced. In the slower growth regions of Canada, the tax credit was greater. In Saskatchewan, Manitoba, Northern Ontario, and some regions of Quebec, the tax credit was 71/2%, while in the Atlantic Provinces and the Gaspé region, the credit was 10%.

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[52]Research and Development Tax Policies - A Paper for Consultation" Department of Finance (1983)

On April 10^{th}, 1978, a proposal to allow taxpayers to deduct from their income an additional 50% of R&D expenditures (current and capital) in excess of the average over the previous three years' expenditures was put forth. The intention was that such an incentive would encourage firms to increase their R&D expenditures, rather than simply benefiting from what they were already spending. On November 16^{th} of the same year, what was to be the last significant change to R&D tax laws for 5 years was made. The R&D tax credit previously available was doubled for all the regions in Canada. This meant that the minimum R&D tax credit was now 10%, while it was as high as 20% in some regions. Further, in order to target small business corporations, an R&D tax credit of 25% was introduced for them.

With the rules as described above in place, two significant problems existed. First, although the 50% additional allowance was designed to encourage additional R&D, it actually encouraged firms to stagger their R&D expenditures, leading to huge expenditures in some years and small expenditures in others. Second, because many firms found themselves unable to use the tax incentives available to them, a form of financing called Scientific Research Investment Contracts (SRIC's) was developed.

In this form of financing, a contract between an outside investor and an R&D performer would be formed. The contract would be formed such that the outside investor would accumulate all the R&D incentives available. Particularly, since the outside investor would typically have no previous R&D expenditures, it would be entitled to the 50% additional deduction on its entire investment. Clearly, this was not what the government had in mind when it originated its incentive system. For these reasons, on April 1983, several changes to the treatment of R&D expenditures were proposed, and were passed into law on October 28th later that year.

First, the budget proposed that 20% of unuseable tax credits (40% for small businesses) be made refundable. At the time, this amendment was to last until May, 1986. Second, investment tax credits could now be carried back three years, and carried forward seven years (instead of five). Furthermore, the limit on the amount of tax credits that a firm could claim in a year ($15,000 plus one half of taxes otherwise payable) was removed. In order to eradicate the roller coaster spending affect that the additional 50% deduction was causing, the government also proposed replacing this allowance with an increased tax credit: from 10% to 20% for most locations, from 20% to 30% for Atlantic Canada, and from 25% to 35% for small businesses.

Finally, a special credit called the Scientific Research Tax Credit was introduced in the budget. Because of the great abuses this incentive program became victim of, and the media attention it drew, a detailed discussion following the review of the history of R&D tax laws in Canada is devoted to it.

Subsequent to this budget announcement, but prior to the next major revision of the tax treatment of R&D, came an announcement on February 15th, 1984, that the SRTC program would only remain for certain equity shares. Furthermore, the 35% credit available to small businesses would only apply to the first $2 million of eligible expenditures.

The release of the May 23rd, 1985 budget unveiled a ruling that would allow for the full refundability of the tax credits in respect of the first $2 million of R&D

expenditures by small business corporations. The other credits would remain refundable at 40%. However, small companies were not the only firms affected by the budget changes which also addressed two other issues. The budget proposed two changes to the concept of what constitutes R&D. First, the test for the eligibility of R&D expenditures would change from "wholly attributable to research and development" to "all or substantially all attributable to research and development."[53] By relaxing the requirement for eligibility, capital equipment used occasionally for purposes other than for R&D would not be immediately disqualified from R&D tax incentives. Second, "[t]he 1985 budget also announced that the R&D incentives would be recast as being in respect of Scientific Research and Experimental Development (SR&ED) rather than simply scientific research."[54] The legal and financial consequences of this second change are likely insignificant as the new term is explicitly defined the same as the old term under regulation 2900 of the income tax act.

In the budget of May 1986, the deadline for investments generating tax credits was extended from May 1986 until 1988. Subsequent to the budget, but prior to a press release issued by the Federal Government on October 9th, 1986, were several draft proposals to change the definition of research in federal tax laws. The Canadian Advanced Technology Association (CATA) strongly objected to an information circular issued on August 29th, which stated that R&D had to involve technological uncertainty in order to qualify.[55] The

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[53] May 23, 1985 Budget

[54] Lalonde (1992) p 7

[55] Globe & Mail, October 3, 1986. B14.

industry felt that this requirement would severely restrict the number of R&D projects that would be eligible for tax credits under these new interpretations of the law.[56] After meeting with CATA representatives, Revenue Canada issued a press release on October 9th. Through this release, the government declared that the technological uncertainty required by a project was a broadly based definition including such uncertainties as the costs of production.

The next significant announcement affecting the tax treatment of R&D expenditures occurred on June 18th, 1987. At this time, two potentially significant rulings were made. First, buildings were excluded for eligibility for SR&ED incentives, and perhaps more importantly, limits were placed on the amount of credits that a firm could declare in a given year. Whereas firms were previously allowed to declare tax credits up to the amount of taxes otherwise payable, they were now limited to a maximum credit of 75% of taxes otherwise payable. At the same time, the carry forward period for investment tax credits was extended from 7 to 10 years. In addition to these changes, the requirement that the R&D a firm undertakes must be related to its business in order to qualify for incentives was intensified.[57]

In 1988, the government introduced a mechanism that allowed firms with proven track records of R&D expenditures to more quickly receive their SR&ED tax credit refunds.

Although the government had already relaxed the "wholly attributable" rule in

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[56]Farwell (1987) 7:7

[57]Lalonde (1992) p.9.

1986, "the government continued to receive representations with respect to two main issues -- uncertainty in relation to directly related expenditures and dissatisfaction with the 'all or substantially all' test for capital expenditures."[58] Accordingly, the Federal Government in 1991 announced that they would soon look into clarifying these areas of the law. However, the issue was not resolved in the February 1992 budget despite the governments reaffirmation "to encourage scientific research and experimental development."[59]

Finally, on October 5th 1992, draft regulations favorably clarifying the definition of SR&ED were released. At the same time, a number of proposals aimed at simplifying the treatment of overhead expenses were made.

The central definition change included clarifying the phrase "all or substantially all." It was now deemed to refer to intent rather than actual usage. Further, the usage could be measured either by time, or value. A second important change dealt with the issue of shared property. Whereas previously only property that was "wholly attributable" to R&D was eligible for SR&ED credits, now shared equipment could also be included (at a reduced rate).

The treatment of overhead expenses before the budget release was disadvantageous to small companies as they seldom had overhead expenses that could be completely related to R&D expenditures, and were therefore not permitted to deduct them. Consequently, firms now have the option of electing for a new proxy method of applying

[58] Lalonde (1992) p.14.

[59] Sapona (1993) p.255

for R&D incentives. Under this method, firms face a narrower set of allowable R&D expenses, but are allowed claiming a standardized 65% of SR&ED base salaries as an overhead expense.

The Scientific Research Tax Credit

The SRTC program was developed by the Federal Government in order to increase the rewards of investing in R&D. The program worked by allowing a corporation to forego tax deductions and tax credits otherwise available to firms conducting R&D, instead passing them on directly to investors in the form of a 50% federal tax credit.[60] Interestingly, the investor was able to use the credit immediately, even before the firm carried out any R&D. At this point, the firm would face a tax liability equal to the credit earned by the investor. However, once the invested money was spent on R&D, the firms liability would disappear.

The program was supposed to work by allowing a firm to generate funds from outside investors without having to pay a huge cost of capital.[61] In turn, this would allow firms to undertake projects that would otherwise be too expensive to undertake. That is, with this new measure, the cost of capital for the new project could be reduced significantly, allowing previously negative net present value (NPV) projects to become positive NPV projects.

For example, consider a firm debating the merits of an R&D project that requires

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[60]The investment could be either in the form of debt or equity

[61]R&D projects are often financed by internal funds because of the high cost associated with acquiring outside sources of capital See for example Himmelberg and Peterson (1994) and Switzer (1984)

an initial investment of one million dollars. For illustration purposes assume:

i) that the firm is unable to finance the project with internal cash flows

ii) that the project is expected to yield cash flows of $400,000 at the beginning of years 2,3,4, and 5

iii) that in order to invest in this "risky" project, outside investors demand a risk adjusted rate of return of 24%

iv) that insiders feel a more appropriate discount rate would be 15%[62]

According to the insiders, the project has an NPV of $142,000 while according to the outsiders, it has an NPV of -$38,230. Under normal circumstances, the outside investors would not be willing to undertake the project. As a result (at least according to the insiders) management would not be able to maximize the value of the firm.

However, given that the outside investors would be able to receive an immediate tax credit of $500,000 their net investment would only be $500,000, and the investment would have an NPV of $461,720.

Note that in this illustration, a short project of only four years was taken into consideration. Normally, corporate R&D investments are longer term. Consequently, the valuation discrepancy between insiders and outsiders (caused by different discount rates) would in fact be more extreme than shown in this example. Correspondingly, the SRTC program had the potential to allow many otherwise rejected R&D projects to be undertaken.

Unfortunately for the government, for the most part, this was not how the project

[62]Here we are assuming that insiders are better informed than outsiders and have made a better estimate of the true discount rate

was used. Instead, investors developed a strategy later dubbed "the quick flip" that allowed them to make riskless profits. Under the quick flip, for example, an investor could buy one dollar's worth of equity in an R&D company, and in return receive a fifty cent federal tax credit as well as sixty cents worth of redeemable equity shares and another forty cents worth of equity in the company. The investor would then immediately redeem his shares and use his tax credit, giving him an immediate return of $1.10. Meanwhile, the firm would face a tax liability of fifty cents. Since the firm would only have forty cents left in the coffer to invest, it would be unable to spend the required dollar to make back its tax liability. The firm would then (sooner or later) declare bankruptcy. The final result would leave the government with an uncollectible debt, and little if any R&D done. Note that most of the R&D firms used in the quick flip were set up specifically to take advantage of this situation.

All told, a program that was expected to cost approximately $100 - $150 million per year ended up costing the government one billion dollars between its inception date and its effective termination .[63]

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[63]Farwell (1987) 7:3

Gathering the Data

The data used in this study consisted of the daily stock returns of Canadian public corporations that traded on the Toronto Stock Exchange between 1973 and 1992, and were retrieved from the TSE WESTERN tapes. The names of the firms that conducted research and development in Canada during this period were obtained through various means including i) Compustat tape analysis, ii) review of reports prepared by private institutions, and iii) analyses of firms' annual reports.

The Compustat tapes were reviewed for each year between 1972 and 1992 to obtain the names of firms that trade on the TSE and reported research and development expenses on their financial statements. The list of firms obtained, however, was not complete enough to perform as exhaustive an event study as desired. The second step in acquiring the names of firms that performed R&D in Canada involved contacting Evert Communications who had a prepared list of the top 100 R&D spenders from 1987 to present day.[64] Furthermore, the TSE GUIDE was reviewed for each year under consideration, and the names of firms who worked in R&D intensive industries were selected. Finally, the annual reports for the companies that were selected exclusively by the third method were reviewed. Some of these firms did not separately disclose the amount of money that they spent on research and development, instead combining this figure with their cost of goods sold. If the company prominently mentioned R&D in their annual report, then the company was included in the analysis even if they did not disclose the amount of money they spent. Finally, companies that disclosed R&D figures in more

[64] Evert Communications Canada's Top 100 Industrial R&D Spenders 1987-1993.

recent years, and that existed but did not disclose these figures in earlier years were included in the study for all years in which they existed. A list of the companies included in the study can be found in Appendix 4.

It should be noted that most of the R&D undertaken in Canada is performed by a relatively small number of companies. Table 6 shows the concentration of industrial R&D among the top performers in Canada for every fourth year between 1973 and 1993.[65]

Table 6: Concentration (in Percent) of R&D Spending Among The Top Performers

Year	Top 10	Top 25	Top 50	Top 75	Top 100
1973	35	51	64	72	77
1977	36	53	66	73	78
1981	35	52	64	72	76
1985	35	48	58	64	68
1989	35	49	59	65	68
1993	37	49	59	65	69

The top 50 firms (in terms of R&D expenditures) consistently account for about 60% of the total R&D undertaken in Canada. As a result, the number of companies considered in the event studies provides ample information regarding the valuation effects the tax law changes had on Canadian corporations.

The surplus returns generated by the firms in the study were expected to vary according to the amount of money spent on R&D activities relative to the size of the firm.

[65]Statistics Canada no 82-202 p.18.

The greater the percentage of the firm's sales spent on R&D, the higher the expected benefits of R&D tax incentives were. When tax incentives are lowered, these same firms were expected to suffer more. In order to best examine the effects on market values that the announcements caused, it was useful to classify some of the firms that conducted R&D into a separate category, High R&D Firms. Note that the High R&D Firms were also included in the Normal Portfolio. Such a division permits more powerful statements about the affects the announcements had on firms that conduct R&D.

The process of uncovering which firms belonged in the High Portfolio involved two steps. First, the firms for whom data was available were ranked by their R&D to sales ratio. The top 30% of these firms plus any other firm that fell within 1.5% of the R&D/Sales ratio of the lowest ranking firm made the High Portfolio. The selection of the firms for which data was not available was made using information from The Financial Post Survey of Industrials. In order to be classified as a High R&D Firm, a company had to be in a high-tech industry.[66] Second, in the company description provided by the survey, a specific and significant mention of R&D had to be made.

As already mentioned, for the firms for which data was available, an account of the R&D expenditures and sales of the firm was taken. However, a firm's reaction to the announcements might be expected to differ according to more than just its R&D/Sales ratio. Specifically, the ability of a firm to use tax incentives, which varies according to its tax position, was also expected to affect its reaction to the news. Consequently, a

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[66]High tech industries included biotechnology and pharmaceuticals, chemicals, communications, construction and material, electrical and electronics, general manufacturing, transportation, computer industry

firm's current tax payable was also recorded. Finally, because most studies involving research and development firms pay particular attention to the cash flow of the firms in question, these values were also recorded. The R&D expenditures included both current and capital costs, the income tax payable was measured as income tax expense less deferred income taxes, and the cash flow was approximated by net income after taxes plus depreciation and amortization. The values were obtained from the COMPUSTAT data tapes.

Methodology

The effects of the announcements on the portfolios of stocks considered were measured using two different approaches. One approach involved calculating the excess return earned by each stock in the portfolio, standardizing the return, and then averaging the returns to get an average Z statistic. The second approach involved calculating the return of the portfolio itself, and measuring the excess return of the portfolio in the event window. A significance test was then performed on the excess returns.

Method 1

The first approach used to measure the effect of the announcements on stock returns was modelled after a 1993 event study undertaken by Shapiro and Switzer.[67]

In the first step of the analysis, a return generating process following the single

[67]Shapiro and Switzer (1993)

factor market model[68]

$$R_{it} = \alpha_i + \beta R_{mt} + \epsilon_{it} \tag{5}$$

was estimated, where:

R_{it} is the rate of return of firm i on day t,

R_{mt} is the market rate of return on day t,

ϵ_{it} is an error term, assumed to be normally, identically distributed with no serial correlation, zero mean, and constant variance, and

α_i, β_i are coefficients whose estimates are used to create an unbiased forecast of expected future returns.

The total period under consideration was a 241 day interval, where t=0 was denoted as the event date. Equation 5 was then estimated for the period -180 to -60, and the estimates for α_i and β_i (a_i and b_i respectively) are used to predict the expected return ($E(R_{it}) = a_i + b_i R_{mt}$) for each firm for days -60 to +60. The abnormal return earned by firm i on day t ($AR_{i,t} = R_{it} - E(R_{it})$) can then be calculated for each day in the period. The average abnormal return for day t, denoted AAR_t is therefore

$$AAR_t = [\frac{1}{N}] \Sigma_{i=1}^{N} AR_{it} \tag{6}$$

where N is the number of firms, and the cumulative average abnormal return ($CAAR_{dt}$)

[68]Shapiro and Switzer (1993) p.250.

is

$$CAAR_{dt} = \Sigma_{t=t_1}^{t_2} AAR_t \tag{7}$$

where dt is a time interval (t_1,t_2)

If the event date under consideration does not affect firm returns, then both AAR_t and $CAAR_{dt}$ should equal zero. In order to detect whether they are significantly different from zero, the average standardized abnormal return ($ASAR_t$) and the average standardized cumulative abnormal return ($ASCAR_{dt}$) are calculated as

$$ASAR_t = [1/N]\,\Sigma_{i=1}^{N} \frac{AR_{it}}{S_{it}} \tag{8}$$

$$ASCAR_{dt} = \Sigma_{t=t_1}^{t_2} ASAR_t \tag{9}$$

where S_{it} is the square root of AR_{it}'s estimated forecast variance calculated as[69]

$$S_{it}^2 = [S_i^2(1 + \frac{1}{120} + \frac{(R_{mt} - \overline{R_m})^2}{\Sigma_{t=-180}^{t=-60}}] \tag{10}$$

Here, s^2_i is the estimated residual variance from the market model regression for security i, R_m is the average market return over the 120 day period over which the market model was estimated, and R_{mt} is the return to the market portfolio at day t.

[69] Dodd and Warner (1983) p 436.

Finally, the Z-statistics

$$Z(AAR_t) = ASAR_t * N^{1/2} \tag{11}$$

$$Z(CAAR_{dt}) = ASCAR_{dt} * N^{1/2}/(t2-t1+1)^{1/2} \tag{12}$$

are calculated. If each firms standardized abnormal returns are normally and independently distributed across securities and time, then these Z statistics can be used to test for significance. As previously mentioned, this market model approach is well specified even if there is some serial correlation of the event residuals. The event windows tested included days -60 to +60, -60 to 0, -5 to +5, -2 to 0, -1 to 0, day 0, and +1 to 60 relative to the announcement date.[70]

Because each firm was treated independently, it was possible to calculate the percentage (p) of firms that had positive abnormal returns in a given time period. Under conditions where the event being considered is insignificant, p would have an expected value of 50%. In order to test whether the percentage with positive abnormal returns differs significantly from 50, the normal approximation to the binomial is used.[71]

If x is a random variable having a binomial distribution with the parameters n and p, then the moment generating function of :

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[70]In order to perform the regression, a FORTRAN program originally written by Lorne Switzer, but modified to meet the specific requirements of this event study was used The program can be found in Appendix 5 As part of the program, a sign test for significance was also run for both portfolios The results of the sign test are presented along side the results of the event study (Method 1) in Table 8

[71]Freund and Walpole (1987) p 227

$$Z = \frac{(x - np)}{\sqrt{np(1-p)}} \qquad (13)$$

where

n is the number of firms and

p = 0.5 is the probability of a positive abnormal return

approaches that of the standard normal distribution where n is large.[72] The two sided significance levels of this sign tests can be found in Table 7.

Note that for each announcement date, two equally weighted portfolios, the Normal Portfolio, and the High Portfolio, were formed. The Normal Portfolio consisted of all the firms in the sample, while the High portfolio consisted uniquely of the High R&D firms defined according to the criteria described in the Data section. The analyses were performed for both portfolios.

Method 2

In order to account for potential serial correlation, a second method for testing for the significance of the events was employed. In this second method, two equally weighted portfolios were formed. The portfolio composition was identical to the composition in Method I. Several statistical tests were then performed on the residuals of the standard market model (where the firms' returns R_{it} are replaced with the portfolios' returns R_{pt}^{H} and R_{pt}^{L}) for each portfolio and for each event date. Specifically, the residuals' skewness,

[72]The normal distribution is often used to approximate the binomial when both np and n(1-p) are greater than 5

kurtosis, and Durbin-Watson statistics were calculated, and an Engle Arch tests at the first, second, fourth, and tenth lag were performed.

In order to account for the non - normality of the data (especially for the variances' conditional heteroskedasticities) a GARCH(1,1) model was used, in addition to a regular OLS model, in the following regression[73]:

$$R_{pt} = \alpha + B_p R_{mt} + B_d D_t + e_t \tag{14}$$

As with Method 1, the event windows tested included days -60 to +60, -60 to 0, -5 to +5, -2 to 0, -1 to 0, day 0, and +1 to 60 relative to the announcement date.The results from this regression can be found in Appendix 1. The summary statistics of the residuals can be found in Appendix 2. The RATS programs run to yield these results can be found in Appendices 6 and 7 respectively.

Discrepancies Between Method 1 and Method 2

Method 1 and Method 2 should not be expected to yield identical results even if the data are distributed normally. Method 1 implicitly gives a higher weight to firms with lower variances, as each firms own Z statistic is found in order to calculate an average Z statistic. If a firm has a large abnormal return, but also a large residual variance, then it may not significantly affect the $Z(AAR_t)$ nor the $Z(CAAR_{dt})$. Contrarily, such a firm could significantly affect the return of the portfolio without significantly affecting its variance. As a result, such a firm could significantly affect the abnormal return in Method 2. The converse is also true.

[73]An ARCH modelling for event studies is suggested by Bollerslev, Chou, Kroner (1992) p.31.

One of the main advantages associated with the first method employed is that it automatically calculates the excess returns earned over each period considered for each firm. This enables a regression of the abnormal returns earned against firm specific characteristics to be performed.[74] For the firms for which the data was available, a regression of the abnormal returns against R&D to Sales ratio, tax payable to sales ratio, and cash flow was performed. The procedure followed consisted of first regressing the abnormal returns against each independent variable separately. If the variable was at least somewhat relevant (a two sided p-value of 25% or better) then a multiple regression with all relevant independent variables and an interaction effect was performed. Finally, a regression between the independent variables was performed in order to test for multicollinearity. In order to perform the regressions, a standard OLS model was employed.

$$AR_{(t_2-t_1)} = \alpha + \Sigma_{k=1}^{p-1}\beta_k X_{ik} + \epsilon_i \tag{15}$$

where

(t2-t1) is the period under consideration and

p is the number of parameters being estimated

A sample RATS program detailing the regressions performed can be found in Appendix 8.

[74]This regression analysis was only performed for the events dating back to and including 1983, as not enough data was available to provide meaningful results for earlier events

Results

Table 7: Summary of Events and Predicted Effects

Date	Rule Changes	Effect
Pre 1961	Current Expenditures on R&D were fully deductible in the year incurred and capital expenditures were deductible at 33% per annum	
1961	Capital Expenditures were made fully deductible in the year incurred.	
1962-66	An additional deduction of 50% of the current and capital expenditures in excess of the base year (1961) was introduced	
1966-75	The additional 50% tax deduction was replaced by grants under IRDIA (Industrial Research and Development Incentives Act) of 25% of capital expenditures, and 25% of current expenditures in excess of the average level over the previous five years	
1975	IRDIA repealed under gvt restraint exercise	
770331	Investment tax credit of 5 to 10% on current and capital expenditures was introduced	positive
780410	An additional tax allowance of 50% of current and capital expenditures in excess of the average level over the previous three years was introduced.	positive
781116	Minimum investment tax credit was raised to 10%, 20%in Atlantic Canada and Gaspe region, and 25% for small businesses	positive
830419	Proposal to eliminate the incremental allowance but increase the R&D tax credit by 10%	positive
831028	Passage into law and release of the proposal to eliminate the incremental allowance but increase the R&D tax credit by 10%.	positive
841010	Effective elimination of the SRTC in the budget release and negative vibrations toward R&D appear in media	negative
850523	The requirement for eligibility of R&D expenses was relaxed	positive

CTD..

Table 7: Summary of Events and Predicted Effects

Date	Rule Changes	Effect
861009	Lobbying against the requirement of "technological uncertainty" for R&D expenses leads to a government release that broadens the definition of "technological uncertainty"	uncertain
870618	Buildings were excluded from SR & ED incentives and restriction were introduced on the amount of ITC's claimable in a year. The carry-forward period for credits was increased from 7 years to 10 years.	negative
920225	Rule clarification regarding the admissibility of R&D expenses expected by the industry but does not appear in budget release.	negative
921005	Favorable clarification of the definition of R&D appears in budget release.	positive

Table 7 provides a summary of the events investigated, and the predicted effects that the events will have on the value of the portfolios.

Table 8
Selection of Relevant Periods
Abnormal Returns, Significance Levels, and Sign Tests

Date: 921005

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 0	Normal	-6.14%	0.044	0.150
	High	N/S	N/S	N/S
Day 0	Normal	-1.34%	0.005	0.001
	High	-2.51%	N/S	N/S
+1 to 60	Normal	8.51%	0.011	0.055
	High	21.22%	0.000	0.074

Date: 920225

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 0	Normal	20.96%	0.000	0.002
	High	33.97%	0.000	0.012
Day 0	Normal	-0.92%	0.067	0.001
	High	N/S	N/S	N/S
+1 to 60	Normal	-11.87%	0.002	0.012
	High	-20.09%	0.016	0.039

Date: 870618

PERIOD	Portfolio	CAAR	P value	Sign Test
+1 to 60	Normal	N/S	N/S	N/S
	High	-17.96%	0.055	0.011

Date: 861009

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 60	Normal	-9.73%	0.004	0.612
	High	N/S	N/S	N/S
-60 to 0	Normal	-5.17%	0.030	0.063
	High	N/S	N/S	N/S
+1 to 60	Normal	-4.55%	0.051	0.398
	High	N/S	N/S	N/S

Date: 850523

PERIOD	Portfolio	CAAR	P value	Sign Test
+1 to 60	Normal	N/S	N/S	N/S
	High	17.63%	0.014	0.096

Table 8 CTD...

Table 8
Selection of Relevant Periods
Abnormal Returns, Significance Levels, and Sign Tests

Date: 841010

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 60	Normal	N/S	N/S	N/S
	High	-15.43%	0.012	0.035
-5 to 5	Normal	N/S	N/S	N/S
	High	-4.60%	0.036	0.035
Day 0	Normal	-1.01%	0.008	0.056
	High	N/S	N/S	N/S

Date: 831028

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 60	Normal	N/S	N/S	N/S
	High	23.45%	0.064	N/A
+1 to 60	Normal	N/S	N/S	N/S
	High	17.00%	0.084	N/A

Date: 830419

No significant abnormal returns earned

Date: 781116

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 60	Normal	-14.97%	0.041	0.090
	High	N/S	N/S	N/A
-60 to 0	Normal	-12.30%	0.017	0.090
	High	-15.15%	0.073	N/A
-5 to 5	Normal	-4.57%	0.028	0.000
	High	N/S	N/S	N/A

Date: 780410

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 60	Normal	3.93%	0.037	0.020
	High	N/S	N/S	N/A
-5 to 5	Normal	N/S	N/S	N/S
	High	7.14%	0.009	N/A
+1 to 60	Normal	8.76%	0.005	0.005
	High	7.15%	0.015	N/A

Table 8 Ctd...

Table 8
Selection of Relevant Periods
Abnormal Returns, Significance Levels, and Sign Tests

Date: 770331

PERIOD	Portfolio	CAAR	P value	Sign Test
-60 to 60	Normal	19.40%	0.034	0.052
	High	54.01%	0.001	N/A
-60 to 0	Normal	N/S	N/S	N/S
	High	31.60%	0.011	N/A
Day 0	Normal	N/S	N/S	N/S
	High	2.49%	0.028	N/A
+1 to 60	Normal	N/S	N/S	N/S
	High	22.41%	0.026	N/A

The windows with statistically significant returns have been compiled for both the Normal and the High portfolios. The cumulative abnormal returns earned, their two sided significance levels, and the two sided significance levels for the sign tests are provided.

N/S indicates an insignificant return.
N/A indicates that the test is not applicable.

Table 9

Regression of Abnormal Returns Against Firm Specific Characteristics

Date: 921005 Day -60 to day 0	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	0.31	0.79	0.44	-0.01
TAX (Simple Regression)	1.70	1.52	0.14	0.04
R&D (Multiple Regression)	0.34	0.89	0.23	0.03
TAX (Multiple Regression)	1.74	1.55	0.23	0.03

Date: 921005 Day 1 to day +60	Beta	t-stat	F(sig)	R2(corrected)
R&D (Simple Regression)	1.24	2.94	0.01	0.20
TAX (Simple Regression)	0.59	0.43	0.67	-0.03
R&D (Multiple Regression)	1.25	2.94	0.02	0.19
TAX (Multiple Regression)	0.76	0.62	0.02	0.19

Date: 920225 Day -60 to day 0	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	0.58	0.64	0.53	-0.02
TAX (Simple Regression)	-5.85	-1.37	0.18	0.03
R&D (Multiple Regression)	0.36	0.39	0.39	0.00
TAX (Multiple Regression)	-5.52	-1.25	0.39	0.00

Date: 920225 Day 1 to day +60	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	-0.78	-1.23	0.23	0.02
TAX (Simple Regression)	-2.80	-0.90	0.37	0.00
R&D (Multiple Regression)	-0.93	-1.44	0.25	0.03
TAX (Multiple Regression)	-3.65	-1.18	0.25	0.03

Date: 870618 Day -60 to day +60	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	-2.41	-2.20	0.17	0.06
TAX (Simple Regression)	1.10	0.56	0.22	0.03
R&D (Multiple Regression)	-2.39	-2.05	0.27	0.05
TAX (Multiple Regression)	0.18	0.10	0.27	0.05

Date: 861009 Day -60 to day +60	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	2.53	1.44	0.17	0.06
TAX (Simple Regression)	-3.03	-1.26	0.22	0.03
R&D (Multiple Regression)	2.05	1.10	0.27	0.05
TAX (Multiple Regression)	-2.22	-0.89	0.27	0.05

Table 9 CTD...

Table 9
Regression of Abnormal Returns Against Firm Specific Characteristics

Date: 850523				
Day -60 to day +60	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	1.34	1.30	0.21	0.04
TAX (Simple Regression)	-3.34	-1.60	0.13	0.08
R&D (Multiple Regression)	1.17	1.16	0.17	0.10
TAX (Multiple Regression)	-3.04	-1.46	0.17	0.10

Date: 841010				
Day -60 to day +60	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	-0.37	-0.25	0.80	-0.06
TAX (Simple Regression)	-0.96	-0.62	0.50	-0.04
R&D (Multiple Regression)	-0.44	-0.29	0.80	-0.10
TAX (Multiple Regression)	-1.00	-0.61	0.80	-0.10

Date: 831028				
Day -60 to day +60	Beta	t-stat	F(sig)	R^2(corrected)
R&D (Simple Regression)	5.19	2.28	0.05	0.28
TAX (Simple Regression)	2.23	0.60	0.56	-0.06
R&D (Multiple Regression)	5.18	2.21	0.12	0.24
TAX (Multiple Regression)	2.19	0.69	0.12	0.24

The coefficients (along with their t-statistics) for the independent variables R&D/Sales and Current Tax Expense/Sales are shown here for both the simple regression and multiple regression models. As well, the significance levels of the regression models and their corrected R squares are also shown. Insignificant correlations between the independent variables indicate that multicollinearity does not exist (results not shown).

Discussion of Event Study Results

The first event date examined was the March 31st, 1977, federal budget announcing the availability of an investment tax credit of 5%[75] on both current and capital research and development expenditures. The credit was received warmly by the financial markets who perhaps saw it as the beginning of a renewed focus on the part of the government to encourage research and development in Canada. In fact, the cumulative average excess returns (CAAR's) earned in both the Normal and the High R&D portfolios were both very large. Over the -60 to +60 day period, the CAAR's in the two portfolios respectively were 19.4% (p value of 0.034) and 54.0% (p value of 0.001). For the High portfolio, three other event windows were found to be significant (-60 to 0, day 0, and 1 to 60).[76]

The following year, on April 10, 1978, the budget released by the Federal Government again called for changes to the treatment of research and development expenditures. Under a new proposal, firms would now be allowed to expense an additional 50% of some of their current and capital R&D expenditures. As illustrated earlier, on an economic level, it might be expected that such a tax ruling would, at least relative to an additional tax credit, more positively affect firms that could significantly increase their R&D expenditures rather than firms that were already close to spending their maximum limit on R&D. Consequently, it could be predicted that the Regular portfolio might react greater to this announcement than would the High portfolio. In fact, this is what was found. Over the sixty day period following the announcement, the

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[75]In some regions, the investment tax credit was 10% of research and development expenditures

[76]The significant windows (for all the event dates) along with their CAAR's and corresponding p-values can be found in Table 8 A p value for the sign test performed can also be found in Table 8

Normal portfolio had a CAAR of 8.76% (p value of 0.005) versus a CAAR of 7.15% (and a p value of 0.015) for the High portfolio .

Over the two 120 day windows related to the just described announcements, the CAAR's for the Normal and High portfolios were 23.3% and 54.0% respectively. The magnitude of such excess returns far outweigh any reasonable prediction of the effect the announcements could have on a company's cash flow. This can be seen by comparing the actual CAAR's earned with the estimates these changes would have on both a high R&D firm (12.56%) and a normal R&D firm (4.98%).[77]

The large CAAR's, therefore, may indicate one of two possibilities: 1) the markets poorly estimated the affect the rulings would have on corporate cash flows, or 2) the market anticipated more favorable tax rulings in the near future. The likelihoods of each possibility will be investigated shortly.

In the November 16th 1978 budget, a proposal to double the investment tax credit for R&D that was made available on March 31st, 1977 was made. This was to be the last budget announcement (until 1983) that significantly changed the tax treatment of research and development expenses. The market response was highly unfavorable in the weeks leading up to the budget speech. In fact, in the normal portfolio, significantly negative CAAR's were observed in three windows (-60 to 60, -60 to 0, and -5 to 5). In the High portfolio, a significantly negative CAAR was observed from day -60 to 0. Over the 120 day period surrounding this announcement, the normal portfolio experienced a loss of almost 15%, while the high portfolio experienced a loss of about 17%.

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[77] Please see Table 5

Why would a positive announcement adversely affect the returns of these companies? The answer likely lies in the abnormally high CAAR's the portfolios earned over the previous two announcements. In fact, it appears that the market was expecting more generous tax breaks than were made available by the Federal Government. Once the market became aware that this tax break would be the last made available for some time, (and it appears that the market became aware of this sometime in the two months leading up to the announcement) they reacted unfavorably toward the portfolios. Clearly, possibility number 2 seems to be supported by the data.

By summing both portfolios (120 day window) CAAR's for the three announcements, an estimation of the market value impact of the three announcements can be made. In fact, the $CAAR_{TOT}$ for the normal portfolio and the high portfolio are 8.36% and 34.64% respectively. By investigating the predicted market effect based on the assumptions outlined in the preceding illustration, we can investigate the reasonableness of the $CAAR_{TOT}$ earned by each portfolio. The estimated excess returns that would be earned as a result of the three previous announcements (assuming a total tax credit of 10% and an additional expense allowance of 50%) are 19.04% for a high R&D firm, and 7.32% for a normal R&D firm.

The estimate for the normal portfolio is quite accurate, while the estimate for the high R&D firms is below the actual CAAR. It should be noted that the estimates were based on very generalized assumptions, which may not hold as well for a small sample of stocks (the high portfolio) as for a larger sample of stocks (the normal portfolio). Particularly, it is possible (and in fact was the case) that one firm had a significantly high set of returns during this time period, which had the affect of overstating the importance of the tax incentives announced. Furthermore, some firms in both portfolios would be eligible for more than the 10% tax credit assumed in the estimation made. Therefore they would be expected to earn returns higher than those predicted.

The next significant draft changes to the treatment of R&D were announced on April 19th, 1983 The significant changes included eliminating the incremental allowance established in 1978, eliminating the limits on the deductibility of income tax credits claimable in a given year, lengthening the carry forward and carry backward periods for unused credits, and increasing all tax credits available for R&D expenditures by 10%. Furthermore, the scientific research tax credit (SRTC) discussed earlier was proposed at this time.

At the time of the proposal, neither the markets nor the media reacted to the news In fact, despite the government's release of a detailed tax paper describing the proposed changes to the tax law, none of the windows for either of the portfolios showed significant CAAR's.

A likely reason for the indifference surrounding the announcement is that the market had learned from it's overreaction mistake in the 1970's, and was unwilling to react to the news until the draft proposal was passed into law on October 28th of the same year. On October 28th 1983, a Globe & Mail article entitled "Approval greets Ottawa's R and D tax proposals " confirmed that "[t]he technology private sector and tax consultants have reacted positively" to the amendments to the income tax act. Over the 120 day window for the high portfolio, a CAAR of 23.45% was earned (p-value of 0.064). Over the same window, the normal portfolio earned a statistically insignificant return.

These returns are as one might expect given the changes in the tax law. As previously noted, an allowance to overexpense increases in research and development expenditures is potentially more valuable to the normal portfolio than is a tax credit, whereas a tax credit is substantially more valuable to a high R&D firm.. We would therefore expect the normal portfolio to react less positively to the news than would the high portfolio. Furthermore, the increase in the flexibility with which unused R&D tax credits could be employed would benefit mostly firms with very high accumulated tax credits. Such firms would mostly be found in the High portfolio.

The results obtained from regressing the firms' excess returns against their firm specific characteristics (R&D to sales ratio and current income taxes payable) showed two things.[78] First, as might be expected, as an average firm's R&D to sales ratio increases, so does it's expected excess return. Specifically, in the single factor regression model using R&D/Sales as the independent variable, β_1 = 5 19 and has a significance level of 4.56%. When Tax is added to the model, it is found to have a beta coefficient of 2.18, but is statistically insignificant (56%). The sign of the beta for tax indicates that firms paying more tax benefit more from these rule changes. Had no changes to the flexibility with which R&D incentives could be used been made, one might expect that the additional 10% credit would be significantly more beneficial to firms paying higher taxes. The increase in flexibility, although not large enough to change the sign of the beta for tax, perhaps prevented the beta from being significantly different from zero.

[78]The results obtained from regressing abnormal returns earned against firm specific characteristics can be found in Table 9

Leading up to the budget release of October 1984 was a media blitz that severely criticized the Federal Government for its SRTC blunder. Articles appearing in the Globe and Mail described the SRTC program as a "tax break [designed] in such a way that there is no control over the way in which close to a billion dollars ... will be spent,"[79] and declared that the program would benefit "mainly financial middlemen partly at the expense of companies engaged in R&D."[80]

Over the 120 day period surrounding the October 1984 budget release (which would effectively stop the SRTC program) significantly negative CAAR of 15.43% (p value of 0.012) was earned by the high portfolio. Two possible explanations exist for this negative return. First, as shown earlier, the SRTC program was potentially valuable to legitimate R&D firms as it may have permitted them to fund NPV positive projects that they otherwise could not have. However, given that other studies described in this paper have shown that only a minor increase in R&D expenditures result from R&D incentive programs, this is unlikely to be the case. Rather, these negative returns were likely caused by the negative vibrations toward R&D that was prevalent in the business world at the time, rather than any real detrimental affect from the budget itself. It is also quite possible that the market predicted the government would be unlikely to unveil any generous R&D incentive programs in the near future given the enormous cost of their most recent failed effort.

The general ill feeling (as oppose to a specific complaint) toward R&D firms is

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[79]Globe and Mail June 11, 1984 M1

[80]Globe and Mail July 13, 1984 B1

also supported by the regression of the firms' excess returns against their firm specific characteristics. In fact, no significant betas were found for neither the R&D/Sales ratio, nor the Tax variable.

This explanation is also consistent with the CAAR's earned over the next announcement period. On May 23rd 1985, the budget announcement that relaxed the requirement for eligibility of R&D expenses was made. Whereas the affects of the previous announcements were witnessed either exclusively before, or both before and after (-60 to +60 window) the announcements made, this announcement came as a surprise to the market. This, as mentioned earlier, is consistent with the notion that the market was not expecting the government to release favorable news to research and development firms after the SRTC catastrophe. The final affect was to create a CAAR of 17.63% (p value of 0.014) for the high portfolio in the sixty days following the announcement. The normal portfolio earned a statistically insignificant return of 4,59% during the same period.

The loosening of the eligibility requirements for R&D might be expected to benefit firms that used some of their capital equipment primarily for R&D, but occasionally for other purposes. This would include mostly young firms that were not yet able to afford equipment that could be used exclusively for R&D. Consequently, such a rule change might be expected to help mostly not only R&D rich firms, but also less profitable (established) firms. These predictions are consistent with the regression analysis. In the multiple regression model, the betas for R&D/Sales and Tax respectively are 1.17 (p-value 26%) and -3.05 (p-value 16.4%).

Leading up to a press release issued by the Federal Government on October 9th, 1986, were several draft proposals to change the definition of research in federal tax laws. The Canadian Advanced Technology Association (CATA) strongly objected to an information circular issued on August 29th, which stated that R&D had to involve technological uncertainty in order to qualify.[81] The industry felt that this requirement would severely restrict the number of R&D projects that would be eligible for tax credits under these new interpretations of the law.[82] After meeting with CATA representatives, Revenue Canada issued a press release on October 9th. Through this release, it became clear that the technological uncertainty required by a project was a broadly based definition including such uncertainties as the costs of production. However, the bitter arguing in the press between the tax collector, and R&D firms may have worsened a mutual feeling of distrust between the two parties that arose from the SRTC fiasco about two years earlier.[83]

Unfortunately for the research and development firms, although the argument between them and Revenue Canada may have been won on paper, they still suffered financial losses. Over the 120 day window surrounding the press release, a CAAR of -9.73% was lost by the normal portfolio (p-value of 0.004).

The results of the regression analysis might be expected to show that firms performing less "technologically uncertain" work might be expected to perform worse than

[81] Globe & Mail, October 3, 1986 B14.

[82] Farwell 7 7

[83] Financial Post October 18, 1986

purer R&D firms. In fact, this is what the results show as the beta for R&D/Sales is 2.53 (p-value of 16.8%) indicating that high R&D firms were less adversely affected by the news than were low R&D firms. The beta for tax in the single factor model was found to be -3.03 (p-value of 22.3%). When the two factor model is used, the betas for the two independent variables are 2.05 and -2.22 respectively.

The next significant announcement affecting the tax treatment of research and development expenditures occurred on June 18th, 1987. At this time, two potentially significant rulings were made. First, buildings were excluded for eligibility for SR&ED incentives, and perhaps more importantly, limits were placed on the amount of credits that a firm could declare in a given year. Whereas firms were previously allowed to declare tax credits up to the amount of taxes otherwise payable, they were now limited to a maximum credit of 75% of taxes otherwise payable. At the same time, the carry forward period for investment tax credits was extended from 7 to 10 years. Such a rule change could be expected to most adversely affect firms that conduct the largest amount of R&D. Articles appearing in the Financial Post[84] and the Toronto Star[85] described the tax reform plans as "discouraging," and stated that they would most severely "penalize the companies performing the most research and development." The market data confirm this picture. In the 60 day period following the announcement, a CAAR of -17.96% was lost by the high portfolio (p-value of 0.055). The normal portfolio, whose member firms would mostly not be affected by this ruling, suffered no loss in the same period.

[84]Financial Post October 26, 1987

[85]Toronto Star August 29, 1987

As for the firm specific regression analysis, financial theory would predict that the firms hurt most by this ruling would include firms that do a large amount of R&D, and firms that pay very little tax. These firms are the ones most likely to be affected by the ruling limiting the amount of R&D credits that could be used in a year. Once again, the regression results are consistent with theory. The betas for R&D/Sales and Tax in their respective single factor models are -2.41 (p value of 0.0415) and 1.10 (p value of 0.582)

After receiving continual complaints from the R&D sector regarding the admissibility of R&D claims, the Federal Government in 1991 announced that they would soon look into clarifying this area of the law. It appears that the market believed that these changes would be announced in the February 25th 1992 budget release. In fact, in the two months leading up to this budget release, the normal and high portfolios earned CAAR's of 20.96% (p value of 0.000) and 33.97% (p value of 0.000) respectively.

However, the solution to the problem was not put forth in the budget release. Rather, the government continued to promise that they would deal with the issue (favorably) at a later date. The markets reacted unfavorably to the news. In the sixty day period following the announcement, the portfolios gave back over half their previous gains, falling 11.87% (p value of 0.002) and 20.09% (p value of 0.016) respectively.

The firm specific regressions were carried out for two different periods for this event, the sixty days leading up to the announcement, and the sixty days following it. Leading up to the announcement, the betas for R&D and Tax respectively were 0.58 (p-value of 0.529) and -5.86 (p value of 0.182). In the sixty days following the announcement, the betas were -0.78 (p-value of 0.229) and -2.79 (p-value of 0.374). The fact that the 1992 budget release did not concretely address any issues would allow one to predict that the firm specific characteristics examined, although possibly having some affect on excess returns earned, would not have statistically significant betas. They did not.

When the favorable clarification of the definition of R&D was put forth in October 1992, allowing among other things for the admissibility of shared equipment for R&D incentives, the market reacted positively. This despite the fact that the "proposed changes [did] not reflect any drastic changes in the scope or nature of Canada's ... tax incentives for research."[86] In fact, CAAR's earned by the portfolios were very similar to the losses they experienced after the February budget was released. In the sixty day period following the press report, the normal portfolio and the high portfolio earned excess returns of 8.51% and 21.22% respectively.

Such a ruling would be expected to most positively affect R&D intense firms, and the firm specific regressions confirm this. The betas for both the R&D/Sales variable, and the Tax variable were 1.24 (p value of 0.006) and 0.76 (p-value of 0.54) respectively. In general, profitable firms carrying out large amounts of R&D benefitted more from the rule clarification than did other firms.

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[86] Sapona (1993) p.255

General Overview of Results

The event study results and subsequent regression of abnormal returns demonstrate that i) significant wealth transfers result from government regulation changes as they relate to research and development expenses and ii) these windfall gains and losses can be traced to firm specific characteristics, primarily to R&D expenditures and secondarily to the tax situation of the firm in question. Furthermore, it appears that the regulation changes to R&D seldom surprised the market, and perhaps more importantly, their effects were most obvious over long intervals of time, rather than at one specific moment. This is consistent with the general view on regulation event studies. Because long event windows were necessary to measure the effects of the regulation changes, the correlations between abnormal returns and firm specific characteristics were particularly important, and serve as an indicator that the risks of a Type I error are quite small.

Conclusion

When a government attempts to shape resource allocation in a society, it has as a goal "to achieve a given allocation effect with the smallest possible transfer of wealth."[87] The event studies undertaken here have emphatically demonstrated that while attempting to increase business research and development expenditures in Canada, a great deal of wealth redistribution has resulted.

In fact, an inspection of the event study results has shown that government regulation changes to research and development tax laws have resulted in windfall gains and losses as high as 54% and -20% respectively.[88] Furthermore, the abnormal returns earned by a firm could often be traced to its specific characteristics. Apart from creating these unwanted windfall gains and losses, the government has also added volatility to industries that are inherently risky.

With regard to timeliness, the results of the event study are consistent with other studies investigating the effects of regulation changes. Specifically, the merits of using large event windows to test for abnormal returns caused by regulation changes were witnessed. In fact, the abnormal returns earned were most prominent in 120 day intervals surrounding the event dates, while the event dates themselves were seldom significant.

Have the measures adopted by the government enjoyed any success? Clearly, many firms have benefitted while others have lost from some of the regulation changes. However, it is not the governments purpose to redistribute wealth from the taxpayers to

[87] McFetridge and Warda (1983) p 9.

[88] See High Portfolio 770331 [-60 to +60] and High Portfolio 990225 [+1 to +60]

firms, unless it can strongly justify doing so. While it is no doubt true that research and development yields social returns that far outpace the returns earned by the companies that conduct the research and development, most evidence indicates that government research and development incentive programs have failed. In effect, this means that the government has failed in its mission to reallocate resources more efficiently while minimizing wealth redistribution.

Terrence Corcoran, a columnist for the Globe and Mail recently declared that regarding developing research and development incentives, "Ottawa keeps trying, and Ottawa keeps getting it wrong. Maybe it should stop trying."[89] Combining the results of previous studies (showing the relative ineffectiveness of R&D incentives with regard to their ability to substantially promote R&D expenditures) with the results of this study (showing that the incentive programs are resulting in large wealth transfers) certainly confirms the first part of Corcoran's declaration. However, it may be premature for the government to "stop trying" to promote business research and development.

Almost all agree that the social return from research and development far outweighs the private return earned by the performing firm. In order to most efficiently allocate Canadian resources, the government should ensure that adequate amounts of R&D are performed in Canada. Statistics Canada has provided data that reveal that Canada is not spending as much on R&D as other comparable nations. This remains true despite R&D incentive programs that are among the most generous in the world.

It seems at this point that the Federal Government, if it is to act in the best interest

[89]Corcoran Terrence, Globe and Mail Dec 16, 1994 B11.

of the nation, must radically change its approach to encouraging research and development. Although over the years a variety of measures to increase R&D expenditures have been adopted by the Federal Government, almost all of them have resulted in substantial wealth redistributions without significantly encouraging R&D. Perhaps it is time for a completely different approach to encourage R&D.

Profit maximizing firms must all attempt to maximize shareholders' wealth. This in fact is their very goal. Consequently, such firms are likely to use all regulation changes to their best advantage without consideration of the intent of the law. Fortunately, this does not hold true for all institutions. Universities, institutions where a great deal of most developed nations brainpower resides, do not have as a primary goal profit maximization. Rather, to a great extent, these institutions pride themselves on their ability to create knowledge. Perhaps the government should concentrate more of its efforts to increase R&D in these institutions rather than the private sector.

Of course, doing so would raise additional concerns. For instance, businesses would be quick to declare that much of the R&D performed in universities is of a theoretical rather than a practical nature. Furthermore, placing R&D investment decisions in the hands of universities runs counter to the economic theory that free enterprise is the best method available to allocate resources. However, the huge wealth transfers resulting from the current incentive system is also in stark contrast with economic theory. Given that this method of encouraging R&D consistently counters the spirit of a free enterprise system while failing to adequately encourage R&D, perhaps it is time to investigate the merits of a radically different approach.

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Appendix 1
Abnormal Returns and Significance Levels for Linear Regression and GARCH Models

Date: 921005

PERIOD	Portfolio	Type	CAAR	P value
-60 to 0	Normal	Linreg	-8.95%	0.17
	Normal	Garch	-5.77%	0.37
Day 0	Normal	Linreg	-1.37%	0.05
	Normal	Garch	-1.43%	1.00
	High	Linreg	-2.59%	0.12
	High	Garch	-2.64%	1.00
+1 to 60	Normal	Linreg	10.93%	0.09
	Normal	Garch	15.96%	0.02
	High	Linreg	24.00%	0.11
	High	Garch	24.90%	0.13

Date: 920225

PERIOD	Portfolio	Type	CAAR	P value
-60 to 0	Normal	Linreg	22.63%	0.01
	Normal	Garch	33.73%	0.00
	High	Linreg	43.90%	0.04
	High	Garch	64.20%	0.00
+1 to 60	Normal	Linreg	-16.76%	0.04
	Normal	Garch	-16.18%	0.08
	High	Linreg	-30.35%	0.15
	High	Garch	-32.80%	0.13

Date: 870618

PERIOD	Portfolio	Type	CAAR	P value
+1 to 60	High	Linreg	-17.78%	0.07
	High	Garch	-11.61%	0.23

Date: 861009

PERIOD	Portfolio	Type	CAAR	P value
-60 to 60	Normal	Linreg	-9.68%	0.26
	Normal	Garch	-11.37%	0.16
-60 to 0	Normal	Linreg	-3.63%	0.47
	Normal	Garch	-4.28%	0.32
+1 to 60	Normal	Linreg	-2.84%	0.56
	Normal	Garch	-3.99%	0.39

Appendix 1 CTD...

Appendix 1
Abnormal Returns and Significance Levels for Linear Regression and GARCH Models

Date: 850523

PERIOD	Portfolio	Type	CAAR	P value
+1 to 60	Normal	Linreg	17.82%	0.03
	Normal	Garch	19.44%	0.01

Date: 841010

PERIOD	Portfolio	Type	CAAR	P value
-60 to 60	High	Linreg	-16.47%	0.20
	High	Garch	-12.00%	0.35
-5 to 5	High	Linreg	-4.09%	0.14
	High	Garch	-3.89%	0.25
Day 0	Normal	Linreg	-1.00%	0.03
	Normal	Garch	-0.01%	1.00

Date: 831028

PERIOD	Portfolio	Type	CAAR	P value
-60 to 60	High	Linreg	25.77%	0.11
	High	Garch	27.83%	0.15
+1 to 60	High	Linreg	14.72%	0.11
	High	Garch	11.51%	0.26

Date: 830419

No significant abnormal returns earned

Date: 781116

PERIOD	Portfolio	Type	CAAR	P value
-60 to 60	Normal	Linreg	-15.25%	0.18
	Normal	Garch	-11.07%	0.35
-60 to 60	Normal	Linreg	-11.93%	0.07
	Normal	Garch	-8.99%	0.17
	High	Linreg	-14.43%	0.24
	High	Garch	-13.97%	0.23
-5 to 5	Normal	Linreg	-4.04%	0.11
	Normal	Garch	-3.56%	0.11

Appendix 1 CTD...

Appendix 1
Abnormal Returns and Significance Levels for Linear Regression and GARCH Models

Date: 770331

PERIOD	Portfolio	Type	CAAR	P value
-60 to 60	Normal	Linreg	18.95%	0.11
	Normal	Garch	12.06%	0.30
	High	Linreg	53.40%	0.05
	High	Garch	50.40%	0.04
-60 to 0	High	Linreg	23.67%	0.13
	High	Garch	30.62%	0.04
Day 0	High	Linreg	2.26%	0.19
	High	Garch	2.22%	1.00
+1 to 60	High	Linreg	11.68%	0.45
	High	Garch	3.60%	0.80

The windows with statistically significant returns (under either Method 1 or Method 2) have been compiled for both the Normal and the High portfolios. A comparison of the linear regression and GARCH results shows that overall, the two models yield similar results except for Day 0. When these one day windows are investigated, the GARCH analysis consistently shows a large variance for the abnormal return causing it to be statistically insignificant.

By comparing the results of Method 1 with Method 2, it can be seen that Method 1 results in higher significance levels. This phenomena, as mentioned before, is not particularly troubling. Rather, it serves as an indication that overall, the firms most affected by the regulation changes had generally lower variances of return (more specifically, lower levels of diversifiable risk). As a result, on an individual level, they had high standardized cumulative abnormal returns, ultimately resulting in high $Z(CAAR_{st}$'s).

Appendix 2
Summary Statistics on Market Model Residuals

Date: 921005
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	1.94	N/S
Skewness	0.81	0.00
Kurtosis	6.13	0.00
Chi-Squared (1)	0.23	0.63
Chi-Squared (2)	0.22	0.89
Chi-Squared (4)	3.32	0.51
Chi-Squared (10)	41.55	0.00

Date: 921005
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.14	N/S
Skewness	6.66	0.00
Kurtosis	1.03	0.00
Chi-Squared (1)	2.57	0.11
Chi-Squared (2)	3.27	0.19
Chi-Squared (4)	7.29	0.12
Chi-Squared (10)	42.75	0.00

Date: 920225
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.28	N/S
Skewness	1.41	0.00
Kurtosis	7.11	0.00
Chi-Squared (1)	0.18	0.67
Chi-Squared (2)	0.19	0.91
Chi-Squared (4)	1.44	0.84
Chi-Squared (10)	5.22	0.87

Date: 920225
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.43	neg. corr.
Skewness	1.65	0.00
Kurtosis	8.94	0.00
Chi-Squared (1)	1 64	0.20
Chi-Squared (2)	1.65	0.44
Chi-Squared (4)	1.90	0.75
Chi-Squared (10)	7.25	0.70

Date: 870618
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.15	N/S
Skewness	1.10	0.00
Kurtosis	6.53	0.00
Chi-Squared (1)	1.02	0.31
Chi-Squared (2)	1.13	0.57
Chi-Squared (4)	1.16	0.88
Chi-Squared (10)	3.15	0.98

Date: 870618
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.09	N/S
Skewness	0.97	0.00
Kurtosis	6.24	0.00
Chi-Squared (1)	2.30	0.13
Chi-Squared (2)	2.29	0.32
Chi-Squared (4)	18.64	0.00
Chi-Squared (10)	22.18	0.01

Date: 861009
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.09	N/S
Skewness	0.08	0.60
Kurtosis	3.32	0.32
Chi-Squared (1)	4.95	0.03
Chi-Squared (2)	4.97	0.08
Chi-Squared (4)	16.35	0.00
Chi-Squared (10)	24.51	0.00

Date: 861009
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.06	N/S
Skewness	0.30	0.06
Kurtosis	4.08	0.00
Chi-Squared (1)	4.07	0.04
Chi-Squared (2)	3.82	0.15
Chi-Squared (4)	5.13	0.27
Chi-Squared (10)	5.68	0.84

Appendix 2 CTD.

Appendix 2
Summary Statistics on Market Model Residuals

Date: 850523
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.04	N/S
Skewness	0.35	0.03
Kurtosis	3.15	0.64
Chi-Squared (1)	0.18	0.67
Chi-Squared (2)	0.54	0.76
Chi-Squared (4)	3.32	0.51
Chi-Squared (10)	12.76	0.24

Date: 850523
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	1.77	N/S
Skewness	0.16	0.32
Kurtosis	3.42	0.18
Chi-Squared (1)	2.78	0.10
Chi-Squared (2)	3.17	0.21
Chi-Squared (4)	3.41	0.49
Chi-Squared (10)	7.17	0.71

Date: 841010
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.10	N/S
Skewness	0.29	0.07
Kurtosis	4.05	0.00
Chi-Squared (1)	0.00	1.00
Chi-Squared (2)	0.06	0.97
Chi-Squared (4)	1.54	0.82
Chi-Squared (10)	3.73	0.96

Date: 841010
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	1.88	N/S
Skewness	0.05	0.77
Kurtosis	3.15	0.63
Chi-Squared (1)	0.63	0.43
Chi-Squared (2)	2.98	0.23
Chi-Squared (4)	6.28	0.18
Chi-Squared (10)	9.90	0.45

Date: 831028
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.25	N/S
Skewness	0.60	0.00
Kurtosis	3.58	0.07
Chi-Squared (1)	0.14	0.71
Chi-Squared (2)	1.90	0.39
Chi-Squared (4)	2.83	0.59
Chi-Squared (10)	8.06	0.62

Date: 831028
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	1.84	N/S
Skewness	0.35	0.03
Kurtosis	1.96	0.00
Chi-Squared (1)	13.95	0.00
Chi-Squared (2)	23.55	0.00
Chi-Squared (4)	24.76	0.00
Chi-Squared (10)	31.80	0.00

Date: 830419
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.06	N/S
Skewness	0.11	0.50
Kurtosis	3.02	0.95
Chi-Squared (1)	3.16	0.07
Chi-Squared (2)	9.00	0.01
Chi-Squared (4)	9.32	0.05
Chi-Squared (10)	18.45	0.05

Date: 830419
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.04	N/S
Skewness	0.35	0.02
Kurtosis	4.54	0.00
Chi-Squared (1)	0.98	0.32
Chi-Squared (2)	1.73	0.42
Chi-Squared (4)	1.93	0.75
Chi-Squared (10)	9.92	0.45

Appendix 2 CTD...

Appendix 2
Summary Statistics on Market Model Residuals

Date: 781116
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.00	N/S
Skewness	0.39	0.01
Kurtosis	2.99	0.98
Chi-Squared (1)	0.09	0.76
Chi-Squared (2)	3.09	0.21
Chi-Squared (4)	6.32	0.18
Chi-Squared (10)	10.03	0.44

Date: 781116
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.31	N/S
Skewness	0.37	0.02
Kurtosis	3.41	0.20
Chi-Squared (1)	0.28	0.59
Chi-Squared (2)	0.31	0.86
Chi-Squared (4)	3.98	0.41
Chi-Squared (10)	10.23	0.42

Date: 780410
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.10	N/S
Skewness	0.23	0.15
Kurtosis	3.92	0.00
Chi-Squared (1)	3.94	0.05
Chi-Squared (2)	4.26	0.12
Chi-Squared (4)	5.46	0.24
Chi-Squared (10)	17.55	0.06

Date: 780410
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.10	N/S
Skewness	0.50	0.00
Kurtosis	5.63	0.00
Chi-Squared (1)	14.67	0.00
Chi-Squared (2)	18.66	0.00
Chi-Squared (4)	25.90	0.00
Chi-Squared (10)	32.70	0.00

Date: 770331
Portfolio Type: Normal

	Value	Sig. Level
Durbin -Watson Stat	2.27	N/S
Skewness	-0.18	0.24
Kurtosis	4.14	0.00
Chi-Squared (1)	6.64	0.01
Chi-Squared (2)	8.71	0.01
Chi-Squared (4)	9.20	0.06
Chi-Squared (10)	16.40	0.09

Date: 770331
Portfolio Type: High

	Value	Sig. Level
Durbin -Watson Stat	2.44	N/S
Skewness	0 25	0.12
Kurtosis	4.85	0.00
Chi-Squared (1)	15.77	0.00
Chi-Squared (2)	16.49	0.00
Chi-Squared (4)	17.30	0.00
Chi-Squared (10)	19.85	0.03

These summary statistics provide Durbin - Watson statistics, skewness levels, and kurtosis levels for the market model residuals and indicate that in almost all cases, the data depart substantially from normality. The summary statistics also provide the results of an Engle-Arch test for conditional heteroskedasticity.

Appendix 3
Number of Firms per Portfolio per Event

Event Date	Normal	High
March 31, 1977	13	4
April 10, 1978	15	6
November 16, 1978	17	8
April 19, 1983	28	7
October 10, 1983	30	7
October 10, 1984	33	11
May 23, 1985	34	9
October 9, 1986	34	10
June 18, 1987	35	10
February 25, 1992	60	19
October 5, 1992	61	20

Appendix 4
Names of Firms Included in the Study

ACCUGRAPH
ADVANCED GRAVIS COMP
ALCAN
BC TELECOM
BELL CANADA ENTERPRISES
BIOMIRA
BOMBARDIER INC
CABLESHARE INC
CAE
CANADIAN MARCONI
CELANESE
CINRAM
CIRCO CRAFT CO.
COGNOS
COMTERM INC
CONTL PHARMA CRYOSAN
COREL CORP
DELRINA
DEVELCON ELECTRONICS
DEVTEK CORP
DONLEE MANUFACTURING SERVICES
DRECO ENERGY
ELECTROHOME
EPIC DATA
FEDERAL PIONEER ELECTRIC
FLEET AEROSPACE CORP
GANDALF TECH
GEAC COMPUTER
GLENAYRE ELECTRONICS
GSW INC
HALEY IND
HAWKER SIDDELEY
HAWKER SIDDELEY
HAYES DANA
HELIX CIRCUITS
HYAL PHARMA
INCO
INTER-CITY PRODS
INTER. SEMITECH MICRO ELECTRONICS
INTERNATIONAL RETAIL SYS
INTERNATIONAL VERIFACT
LAFARGE
LEIGH INSTRUMENTS
LSI LOGIC
LUMONICS
MDS HEALTH GROUP
MERIDIAN TECHNOLOGIES
MITEL
MOORE
NATIONAL PETROLEUM CORP.
NEWBRIDGE NETWORK CORP
NOMA INDUSTRIES
NORTHERN TEL
NOWSCO WELL SERVICE
NOWSCO WELL SERVICE
QUADRA LOGIC TECH
RIO ALGOM
S R TELECOM
SCINTREX LTD
SHAW IND
SHL SYSTEMHOUSE
SICO
SPAR AERO
SUPRIOR ELECTRONICS INDUSTRIES
SYNEX INTERNATIONAL
TEE-COM ELECTRONICS
TELEGLOBE INC
TIE/TELECOMM
TRIMEL CORP
UNITED DOMINION
VAN DER HOUTE ASSOCIATES
VARITY

Appendix 5
FORTRAN Program for Method 1 Analysis

```
      PROGRAM JOG1
C     PROGRAM DIVR_EVENT
C     THIS PROGRAM DOES EVENT ANALYSIS STUFF
C     BY CREATING RESIDUALS AND CUMULATIVE RESIDUALS
C     FROM A STATIC REGRESSION, AND CALCULATES
C     T AND Z STATS FOR REGIME AND SUB-PORTS
C     IN SHARON,
C     DATA IS COPIED TO *DATA WHICH IS USED AS INPUT DCB#7
C     OUTPUT IS IN TWO FORMS. REGULAR PRINTOUT, PLUS A
C     FILE FOR GRAPHING CALLED ACCORDING TO THE REGIME ON UNIT 7
C     FOR EXAMPLE SPLIT DATE OLS REGIME IS FILE AB_SPOLSG
C     G STANDS FOR THE GRAPH,SP STANDS FOR THE SPLIT DATE
C     THUS THE FILES SHOULD HAVE NAMES SUCH AS AB_SPMARAG,
C     AB_ANOLSG,AB_ANMARAG,AB_APOLSG,AB_APMARAG
C     OUTPUT 8 IS FOR THE PORTFOLIO TABLE FILES END WITH A T INSTEAD
C     OF A G FOR EXAMPLE AB_SPOLST
C     UNIT 2 HAS TSE DAILY DATA FILE CALLED TSE300_DRET
C     UNIT 3 HAS THE DATA ON 33 FIRMS FILE CALLED AB_RETURN
C     UNIT 6 IS THE PRINTER UNIT
C     UNIT 7 CREATES A FILE FOR GRAPHIC OUTPUT
C     THE PARAMETERS NFIRM,NR,MARA,MOVORG AND L HAVE TO BE SPECIFIED
C     IN THE DATA STATEMENT ACCORDING TO THE PROBLEM
C
C     SEE THE DESCRIPTION BELOW
      CHARACTER*1 GRAPH(41)
      CHARACTER*8 CUSIP
      CHARACTER*20 COMPNM
      CHARACTER*10 TSE
      CHARACTER*80 LINE
      REAL PEB,MSE
      INTEGER ST(7),EN(7),RELDATE
      DIMENSION NU(121),PE(200,121),CPE(200,121),SPEJT(200,121),
     1 AR(200,121),CPEK(10),WCPEK(10),ARP(121),
     2 U(121),FRMRET(241),USRET (241),
     3 R(2,241)
      DATA ST/1,1,56,59,60,61,62/,EN/121,61,66,61,61,61,121/
       DATA NFRM,NR,MARA,MOVRG,L/83,120,1,2,60/
C
      OPEN ( UNIT = 2, FILE = '770331m.dat', STATUS = 'OLD',
     1     ACCESS = 'SEQUENTIAL', FORM = 'FORMATTED', RECL = 130 )
      OPEN ( UNIT = 3, FILE = '77031.lat', STATUS = 'OLD',
     1     ACCESS = 'SEQUENTIAL', FORM = 'FORMATTED', RECL = 135)
      OPEN ( UNIT = 6, FILE = 'JOGOUT77031.DAT', STATUS = 'NEW',
     1     ACCESS = 'SEQUENTIAL', FORM ='FORMATTED' )
      OPEN ( UNIT = 7, FILE = 'JOGPRN77031.DAT', STATUS = 'NEW',
     1     ACCESS = 'SEQUENTIAL', FORM = 'FORMATTED' )
      OPEN ( UNIT = 8, FILE = 'FOLIO77031.DAT', STATUS = 'NEW',
     1     ACCESS = 'SEQUENTIAL', FORM = 'FORMATTED' )
C
      PRINT*,' INPUT NUMBER OF FIRMS'
      READ*,NFRM
C
C     L=1^ WIDTH OF WINDOW.
C     NR=LENGTH OFREGRESSION, INPUT FROM FIRST RECORD
C     MARA=1: NOT DONE =2: IS DONE
```

CTD...

Appendix 5
FORTRAN Program for Method 1 Analysis

```
C    MOVRG=1 MOVING (STOCH) REGRESSION NOT DONE, =2 DONE.
C    NR+2L+1=#OF DATA POINTS
C    NFRM: #OF COMPANIES
C
     IF (MARA.EQ.1) KRGM1=1
     IF (MARA.EQ.2) KRGM1=2
C
C    SETTING SOME OF THE VARS TO ZERO
C    CONVENTION USED: PE(I,J,K)= ERROR FOR ITH REGIME,
C    JTH FIRM, KTH WEEK
C
     NVAR=NR+2*L+1
       KCOUNT=0
       NW=0
       DO 1000 K=1,(2*L+1)
         NU(K)=0
         DO 1000 J=1,NFRM
           PE(J,K)=0.
           SPEJT(J,K)=0.
           CPE(J,K)=0.
           AR(J,K)=0.
1000  CONTINUE
C    READ MARKET RETURNS
C    DO 1010 J=1,241
     READ (2,17) TSE
17   FORMAT (A10)
     READ (2,23) USRET
C    1010 CONTINUE
1149 READ (3,22,END=1150) compnm
22   FORMAT (/,A20)
C
C    READ FIRM RETURNS
     READ (3,23) FRMRET
23   FORMAT (45X,7F9.5/,19(12F9.5/),6F9.5)
     WRITE(6,22) COMPNM
     WRITE(6,24)FRMRET
24   FORMAT (2X, 12F9.5)
C     KY = RELDATE-180
      DO 1040 J=1,241
        R(2,J)=FRMRET(J)
        R(1,J)=USRET(J)
        IF(R(2,J).LT.-1.0) R(2,J)=0.0
        IF(R(1,J).LT.-1.0) R(1,J)=0.0
C         KY=KY+1
1040    CONTINUE
     WRITE(6,*) ' MARKET RETURN'
     WRITE(6,9999) (R(1,J),J=1,241)
9999 FORMAT(2X,12F9.5)
C     THIS LOOP IS DONE THREE TIMES, ONCE FOR EACH
C     REGIME. PE CPE SPEJT AR LOADED INTO BIG MATRICES.
C     NOTE MOVE REG TREATED LIKE OLS HERE. LATER ON,
C     ALTERATIONS WILL BE MADE.
C    OLS REGRESSION WHERE NR=# OF WEEKS IN REGRES, EVNT=EVENT
C    WEEK. L=1/2 WIDTH OF STUDY PERIOD IE +-L WEEKS.
C
```

CTD .

Appendix 5
FORTRAN Program for Method 1 Analysis

```
C    KRGM IS WHICH REGIME =1: OLS
C                    =2: MARA
C                    =3: MOVING
C
      KRGM=KRGM1
      KCOUNT=KCOUNT+1
        II=0
        SX=0.
        SY=0.
        SXX=0.
        SYY=0.
        SXY=0.
        IJ=0
        DO 1050 I=1,NR
          SX=SX+R(1,I)
          SY=SY+R(2,I)
          SXX=SXX+R(1,I)**2
          SYY=SYY+R(2,I)**2
          SXY=SXY+R(1,I)*R(2,I)
1050      CONTINUE
        D=NR*SXX-SX**2
        A=(SXX*SY-SX*SXY)/D
        B=(NR*SXY-SX*SY)/D
        SLY=SYY-SY**2/NR
        SLX=SXX-SX**2/NR
        R2=(SXY-SX*SY/NR)**2/(SLX*SLY)
        MSE=(1.-R2)*SLY/(NR-2)
        IF (KRGM.EQ.2) MSE=SLY**.5/(NR-2)
        RMSE=MSE**.5
        TB=B/(MSE*NR/D)**.5
        F=TB**2
        WRITE (6,9070) KCOUNT,COMPNM,KRGM,A,B,TB,F,R2,RMSE,SLX,
     1            SLY,SX,SY,SXX,SYY,SXY
C
C    AN AR IS THE ERROR OVER THE ESTIMATION INTERVAL
C    NOTE THAT AN AR MATRIX WILL BE CALCULATED FOR
C    EACH WEEK OF THE MOVE REG:  THIS MAT IS CALLED ARM.
C    REGRESSION NOW DONE.  NEXT LOAD AR'S INTO MATRIX
C    THE FOLLOWING CONVENTION IS USED... EACH FIRM HAS
C    FOUR 'TO' VALUES WHICH TELL WHICH REGIMES THE STOCK
C    IS AGGREGATED INTO.  AR(A,B,C) IS THE BTH COMPANY IN
C    REGIME A FOR WEEK C.
C
       EMSE=0.
       EMSE2=0.
       DO 1070 I=1,NR
         IJ=IJ+1
         IF (IJ.NE.1)GOTO 1060
         NW=NW+1
1060       AR(NW,IJ)=R(2,I)-A-B*R(1,I)
         IF (KRGM.EQ.2) AR(NW,IJ)=R(2,I)-SY/NR
1070     CONTINUE
C    FOR EACH WEEK, CALCULATE PE,CPE,SCPE AND LOAD INTO
C    MATRICES SIMILAR TO ABOVE.  FOR EACH WEEK TYPE OUT
C    U AND CU.
```

CTD

```
        SXE=0.0
        SYE=0.
        SYYE=0.
        DO 1130 I=NR+1,NVAR
          II=II+1
          U(II)=R(2,I)-A-B*R(1,I)
          IF (KRGM.EQ.2) U(II)=R(2,I)-SY/NR
          EMSE2=EMSE2+U(II)**2
        SXE=SXE+R(1,I)
          SYE=SYE+R(2,I)
          SYYE=SYYE+R(2,I)**2.
          CUT=0.
          DO 1100 J=1,II
            CUT=CUT+U(J)
1100        CONTINUE
          DO 1110 JG=1,41
            GRAPH(JG)=' '
1110        CONTINUE
          JJJ=CUT*100./2+21.6
          IF (JJJ.LE.0) JJJ=1
        IF(JJJ.GE.41) JJJ=41
          GRAPH(JJJ)='*'
          JDAY=II-L-1
          SJT=MSE*(1.+1./NR+(R(1,I)-SX/NR)**2/SLX)
          IF (KRGM.EQ.2) SJT=MSE
          SPEJTT=U(II)/SJT**.5
          NU(II)=NU(II)+1
          PE(NU(II),II)=U(II)
          CPE(NU(II),II)=CUT
          SPEJT(NU(II),II)=SPEJTT
          WRITE (6,9080) JDAY,U(II),SPEJTT,CUT,SYE,SXE,GRAPH
1130      CONTINUE
        EMSE=((EMSE2-CUT**2./(2.*L+1.))/(2.*L-1))**.5
        SLYE=(SYYE-SYE**2./(2.*L+1))
        WRITE (6,9090) KCOUNT,EMSE,SLYE,SJT,KRGM
    DO 1470 NSP=1,7
    NADJ=EN(NSP)-ST(NSP)+1
    CPEK(NSP)=0.0
    DO 1450 JDY=ST(NSP),EN(NSP)
    CPEK(NSP)=CPEK(NSP)+PE(KCOUNT,JDY)
 1450  CONTINUE
    WCPEK(NSP)=CPEK(NSP)/((MSE*NADJ)**.5)
 1470 CONTINUE
    WRITE(8,9160) KCOUNT,(CPEK(LZ),LZ=1,7)
    WRITE(8,9160) KCOUNT,(WCPEK(LZ),LZ=1,7)
 9160 FORMAT(I3,7F10.4)
1140    CONTINUE
    GO TO 1149
1150  CONTINUE
C     EACH FIRM HAS BEEN PROCESSED. RESULTS IN BIG MATRICES
C     REGIMES NOW ANALYSED. B SUFFIX MEANS BAR OR MEAN
I=KRGM1
    WRITE(6,9000) NW,NR,MARA,MOVRG,L
    WRITE (6,9100) I, NU(I)
```

CTD ..

Appendix 5
FORTRAN Program for Method 1 Analysis

```
C    S(ARP) CALCULATED: NOTE MOVING REG SARP CALC LATER
C
      ARBAR=0.
      ARX=0
      DO 1170 J=1,NR
        ARP(J)=0
        DO 1160 K=1,NW
          ARP(J)=ARP(J)+AR(K,J)/NW
1160    CONTINUE
        ARX=ARX+ARP(J)**2.
        ARBAR=ARBAR+ARP(J)
1170  CONTINUE
      SARP=((ARX-ARBAR**2/NR)/(NR-2))**.5
C
C    WITH S(ARP), TPE & TCPE & Z CAN BE CALCULATED
C
      COV=0.
      DO 1180 JSW=2,NR
        COV=COV+(ARP(JSW)-ARBAR/NR)*(ARP(JSW-1)-ARBAR/NR)/(NR-1)
1180  CONTINUE
      SCPEB=0.
      DO 1240 J=1,L*2+1
        CPEB=0.
        PEB=0.
        SPEB=0.
        DO 1220 K=1,NU(J)
          PEB=PEB+PE(K,J)/NU(J)
          CPEB=CPEB+CPE(K,J)/NU(J)
          SPEB=SPEB+SPEJT(K,J)
1220    CONTINUE
        SCPEB=SCPEB+SPEB
        TPE=PEB/SARP
        TCPE=CPEB/(SARP*J**.5)
        TCPESW=CPEB/(J*SARP**2.+2*(J-1)*COV)**.5
        DO 1230 JG=1,41
          GRAPH(JG)=' '
1230    CONTINUE
        JJJ=CPEB*100.+21.6
        IF (JJJ.LE.0) JJJ=1
        IF (JJJ.GT.41) JJJ=41
        GRAPH(JJJ)='*'
        ZPE=SPEB/(NU(J)*(NR-2)/(NR-4))**.5
        ZCPE=(ZPE*SCPEB/SPEB)/J**.5
        JDAY=J-L-1
        WRITE (6,9110) JDAY,PEB,TPE,ZPE,CPEB,TCPE,TCPESW,
     1    ZCPE,GRAPH
        WRITE (7,9060) JDAY,PEB,TPE,ZPE,CPEB,TCPE,TCPESW,
     1    ZCPE
1240  CONTINUE
      WRITE (6,9120) SARP
      WRITE (6,9130)
      DO 1270 NSP=1,7
        NADJ=EN(NSP)-ST(NSP)+1
        NDIV=NU(EN(NSP))
        DSJT=0.
```

CTD. .

Appendix 5
FORTRAN Program for Method 1 Analysis

```
      CPESP=0.
      P1=0.
      P2=0.
      DO 1260 JFRM=1,NDIV
        SSJT=0
        DO 1250 JDY=ST(NSP),EN(NSP)
          SSJT=SSJT+SPEJT(JFRM,JDY)
          CPESP=CPESP+PE(JFRM,JDY)/NDIV
1250      CONTINUE
        WJ=SSJT/NADJ**.5
        DSJT=DSJT+WJ
        IF (WJ.GT.0.0) P1=P1+1.
        IF (WJ.GT.2.02) P2=P2+1.
1260    CONTINUE
      ZSP=DSJT/NDIV**.5
      TCPETP=CPESP/(SARP*NADJ**.5)
      P1=P1/NDIV
      P2=P2/NDIV
      TP1=(P1-.5)/(.25/NDIV)** 5
      TP2=(P2-.05)/(.0475/NDIV)**.5
      NSTX=ST(NSP)-61
      NENX=EN(NSP)-61
      WRITE (6,9140) NSTX,NENX,CPESP,TCPETP,ZSP,P1,TP1,P2,TP2
      WRITE (8,9150) NSTX,NENX,CPESP,TCPETP,ZSP,P1,TP1,P2,TP2
1270  CONTINUE
1280  CONTINUE
     STOP
9000  FORMAT(' ',20X,'PART 1, CLASSICAL RESULTS.',/,15X,'NFRM = '
     1,I3,'  NR = ',I3,'  MARA= ',I2,' MOVRG = ',I2,
     1 ' WINDOW= ',I2)
9010  FORMAT(26X,F10.6)
9060  FORMAT(' ',I4,7F10.4)
9070  FORMAT(' ',21X,'COMPANY NUMBER ' I4,2X,A32,//,30X,' REGIME =',I2
     1,/,10X,'ALPHA=',F8.4,' BETA=',F8.4,
     2' T(B)=',F5.2,' F= ',F6.2,' RSQR= ',F4.3,/,18X,' RMSE=',F8.4,
     3' SLX=',F8.4,' SLY=',F8.4,/,18X,'SX= ',F8.4,2X,
     4'SY= ',F8.4,2X,'SXX= ',F8.4,2X,'SYY= ',F8.4,2X,'SXY= ',
     5 F8.4,///,8X,'DAY',8X,'PE',5X,'SPEJTT',6X,
     6 'CPE',8X,'CRY',6X,'CRX',//)
9080  FORMAT(' ',6X,I4,5F10.4,41A1)
9090  FORMAT(' ',/,5X,'END OF ANALYSIS FOR FIRM',I4,6X,'REMSE=',F10.5,
     12X,' SLYE=',F10.5,'SJT= ',F10.5,' REGIME= ',I2,///)
9100  FORMAT(' ',//,15X,'ANALYSIS FOR REGIME',I4,' WITH',I4,
     1' FIRMS INCLUDED',///,3X,'DAY',5X,'PE',6X,'TPE',5X,
     1'ZSPE',4X,'CPE',5X,'TCPE',4X,'TCPESW',2X,'ZSCPE',
     2 3X,41A1)
9110  FORMAT(' ',I5,7F9.4,41A1)
9120  FORMAT(' ',25X,'S(ARP)=',F10.5,//)
9130  FORMAT(' ',25X,'SUB-PERIOD ANALYSIS',/,1X,'FROM',3X,'TO',7X,
     1'CPE',6X,'TCPE',6X,'ZCSPE',7X,'P1',5X,'T(P1)',8X,'P2'
     2,5X,'T(P2)',//)
9140  FORMAT(' ',I4,I5,8F10.4)
9150  FORMAT(I4,I5,8F10.4)
     END
```

Written by Lorne Switzer

Appendix 6
RATS Program for Linear Regression and GARCH Models

```
allocate 0 500
open data c:\rats\data\9210ratd.wk1
data(format=wks, org=obs) 1 241 day  rm ri
smpl 1 241
set dum = day.ge.0.and.day.le.+60
set u = 0.0
set v = 0.0
nonlin b0 b1 b2 a0 a1 a2
frml regresid = ri - b0 - b1*rm  - b2*dum
frml garchvar = a0+a1*u{1}**2+a2*v{1}
frml garchlogl = v(t)=garchvar(t),u(t)=regresid(t),$
   -.5*(log(v)+u**2/v)
linreg ri
# constant rm dum
compute b0=%beta(1),b1=%beta(2),b2=%beta(3),$
  a0=%seesq, a1=.08,a2=.62
nlpar(criterion=value,subiterations=30) 6
maximize(method=bhhh,recursive,iterations=20) garchlogl 2 *
end
```

Written by Lorne Switzer

Appendix 7
RATS Program for Summary Statistics on Market Residuals

```
allocate 0 500
open data c:\rats\data\9210ratd.wk1
data(format=wks,org=obs) 1 241 day rm  ri
linreg ri 1 241 resid
# constant rm
statistics resid 1 241
set ressqr = resid**2
linreg(noprint) ressqr
# constant ressqr{1}
compute chistat=%nobs*%rsquared
cdf chisqr chistat 1
linreg ri 1 241 resid2
# constant rm
set ressqr2 = resid2**2
linreg(noprint) ressqr2
# constant ressqr2{1 to 2}
compute chistat=%nobs*%rsquared
cdf chisqr chistat 2
linreg ri 1 241 resid4
# constant rm
set ressqr4 = resid2**2
linreg(noprint) ressqr4
# constant ressqr4{1 to 4}
compute chistat=%nobs*%rsquared
cdf chisqr chistat 4
linreg ri 1 241 residte
# constant rm
set ressqrte = residte**2
linreg(noprint) ressqrte
# constant ressqrte{1 to 10}
compute chistat=%nobs*%rsquared
cdf chisqr chistat 10
end
```

Written by Lorne Switzer

Appendix 8
RATS Program to Calculate the Beta Coefficients of Firm Specific Characteristics

```
allocate 0 500
open data c:\rats\data\car8706.wk1
data(format=wks,org=obs) 1 20 caer rd tax cf
set inter =(rd*tax)
linreg caer / resid1
# constant rd
statistics resid1
linreg caer
# constant tax
linreg caer
# constant cf
linreg caer / resid2
# constant rd tax
linreg caer / resid3
# constant rd tax inter
statistics resid2
statistics resid3
linreg rd
# constant tax
end
```