AN EXAMINATION OF TIME AND INDUSTRY EFFECTS ON STRASSMANN'S INFORMATION PRODUCTIVITY INDEX: EVIDENCE FROM THE TSE300 INDEX INDUSTRIES

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ABSTRACT

AN EXAMINATION OF TIME AND INDUSTRY EFFECTS ON STRASSMANN'S INFORMATION PRODUCTIVITY INDEX: EVIDENCE FROM THE TSE300 INDEX INDUSTRIES

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The last few decades have been witness to a surge in the use of information technology (IT) in the hope of bettering firm performance, productivity, efficiency, and effectiveness. Increasingly, a firm's decision to invest in IT is deemed critical as it may provide the company with strategic advantages and enhanced productivity. Several studies have endeavoured to link IT investments to firm performance. Although huge sums of money have been invested in IT by firms across all industries, there is still little evidence of a concomitant increase in firm productivity; thus the term "productivity paradox".

The significance of this research lies in that it will try to determine whether certain of the TSE300 Index industries are more effective in their use of IT than others, whether temporal effects play any significant role, and whether there exist any interaction between time and industry. We examine these industry, time and interaction effects by running multiple regression models estimated using Ordinary Least Squares procedure.

The major findings include the following: industry effects are present for all industries when taking all years into consideration, and when looking at individual years, while for 1994 only the paper and forest products industry was reported significant, in 1996, 1997 and 1998, practically all industries reported positive significant results.

Furthermore, when looking at the time effects of the fourteen industries taken together, results report that in 1996, 1997, and 1998 industries made less effective use of their IT than in 1994. This finding was contrary to our expectations and may be as a result of the increased level of technological turnover; users are faced with the challenge of becoming familiar with new technologies, and it may take several years for the effects of the implementation of new technologies to be felt.

Finally, when looking at the time and industry interaction effects, the metals and minerals, the gold and precious minerals, and the real estate industries report negative significant results, while the oil and gas and paper and forest products industries report positive significant results for 1996 and 1997, and 1994 and 1995, respectively, and negative significant results for 1998, and 1996 and 1997, respectively.

In terms of future research, this base of information can be used in order to examine the differences in terms of investment in, use of, adoption, or implementation of IT in information productive industries relative to those that are less effective at using IT.

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INTRODUCTION

The last few decades have been witness to a surge in the use of information technology (IT) in the hope of bettering firm performance, productivity, efficiency, and effectiveness. Increasingly, a firm's decision to invest in IT is deemed critical as it may provide the company with strategic advantages and enhanced productivity.

Several studies have endeavoured to link IT investments to firm performance (see Harris and Katz, 1991; Hitt and Brynjolfsson, 1996; Kivijärvi and Saarinen, 1995; Rai, Patnayakuni, and Patnayakuni, 1997; Weill and Olson, 1989). Although huge sums of money have been invested in IT by firms across all industries, there is still little evidence of a concomitant increase in firm productivity; thus the term "productivity paradox".

The objective of this research is to supplement the productivity paradox literature by using Strassmann's information productivity index (IPI) as an indicator of a firm's productivity. Although this research deals with firms' productivity in general, it specifically focuses on firms listed on the Toronto Stock Exchange (TSE) 300 Index. By considering data between 1994 and 1998, this research attempts to determine whether time and industry effects are significant with respect to a firm's effective use of information technology during these five years..

Although Strassmann has conducted extensive research on IPI at the firm level across industries in several countries, his research has mainly concentrated on the United States; furthermore, to the best of our knowledge, he has never looked at time effects on IPI. This research focuses solely on Canadian firms listed on the TSE 300 Index. Of these three hundred companies, we were able to collect 1091 observations for the 1994-1998 period. We examine industry and time effects, as well as any interaction effects which may exist between time and industry, by running multiple regression models estimated using the Ordinary Least Squares procedure.

This thesis comprises seven chapters. The first chapter presents the concept of the productivity paradox of information technology. It examines the fundamental economic measure of productivity and reviews some of the explanations given for the occurrence of the productivity paradox, namely, the mismeasurement of inputs and outputs, the time lag between the adoption of IT and its effects, the redistribution and dissipation of profits, and the issue of mismanagement. The second chapter examines Strassmann: first, his thoughts, ideas, and concerns about a firm's productivity (and its link to investments in IT), second, his proposed way of measuring a firm's productivity, the IPI, and the rationale behind using this ratio. The third chapter deals with the fourteen industries that make up the TSE300 Index; each is discussed with respect to the extent of its use of IT. The third chapter concludes the literature review of this research.

The fourth chapter looks at the research questions that are to be investigated, namely, whether there is a significant difference in IPIs across industries, whether time affects IPI, and whether there is any interaction between firm classification and time. The fifth chapter examines the research methodology that is used to analyse the hypotheses set out in the previous chapter. In this chapter, the data is described, and the multiple regression models that are estimated using the Ordinary Least Squares procedure are detailed. The sixth chapter provides the results and analysis of the regressions run. The seventh chapter concludes the thesis and sets out future research that could extend this work.

CHAPTER I

The Productivity Paradox Of Information Technology

Over the last few decades, phenomenal growth in information technology has occurred; however, whether a concomitant increase in firms' productivity has resulted remains the topic of much debate. The term 'productivity paradox' refers to the findings of some studies that investments in IT have either not increased productivity or profitability, or that any gains have been offset by inefficiencies somewhere else. Although, admittedly, there has not been much evidence to support that investments in IT lend themselves to increases in productivity, there is equally no evidence linking investments in IT to un-productivity (Brynjolfsson, 1993; Brynjolfsson and Hitt, 1998). While more recently, researchers have offered various explanations for the apparent lack of growth in productivity and profitability pursuant to investments in IT, before reviewing these reasons, the key concepts of productivity will be addressed.

1.1 Productivity

A fundamental economic measure, productivity is the relation between the number or amount of products and services produced and the resources used to create the products and services (Gray and Jurison, 1995). In basic terms, it is the amount of output produced per unit of inputs or the amount of inputs used in producing a given amount of output. While in essence taking the ratio of output to input is straightforward, when there is more than one input (or factor of production) not all of which are necessarily measured in the same unit, the task becomes more complex. Furthermore, even greater complexity results when changes in technologies, product or service specifications, or product or service prices occur, and factors such as labour, capital or investments can be substituted by one another.

Productivity is measured in order to convey to a firm how effectively it uses its resources. To improve productivity, a firm may increase the number (and/or amount) of outputs while holding the number (and/or amount) of inputs constant or, conversely, may hold the number (and/or amount) of outputs constant while decreasing the number (and/or amount) of inputs. In order to measure productivity empirically, quantifiable inputs and outputs are required. In today's economy, output can no longer be defined simply as the tons of steel or the cords of wood produced, and input is more than just labour hours. Increasingly, the value of a firm's output depends on a number of intangibles, including product quality, customer service, timeliness, customization, and convenience. In a similar vein, the quantity and quality of capital equipment used, materials consumed, staff training and education, and investment in IT are all considered inputs. Paradoxically, though much information and data has been collected on numerous inputs and outputs, the task of measuring a firm's productivity has become much more difficult and complex in today's information economy than previously in the industrial economy (Brynjolfsson and Hitt, 1998).

1.2 Productivity Paradox Explained?

In trying to solve the productivity paradox mystery, much research has been undertaken; the result has been a deepening of the mystery. Several explanations as to the seeming occurrence of the productivity paradox have been offered within the literature: (1) the mismeasurement of inputs and outputs, (2) the time lag between the adoption or implementation of IT and the ensuing impact, (3) the redistribution and dissipation of profits within an industry, and (4) mismanagement. We examine each below, in some detail.

1.2.1 Mismeasurement of inputs and outputs

The most common explanation of the productivity paradox of IT maintains that the problem is measurement related. This type of explanation tends to deal with shortcomings in research, not practice. As per Brynjolfsson (1993), while investments in IT may account for extensive benefits, the lack of a true index understates or obscures the productivity growth. Non-traditional sources of value, for example, product quality, timeliness, customization, and variety are not easily measurable by traditional measures. In a like manner, valuable customer services such as convenience and improved working conditions are not taken into account in official output data (Allen, 1997).

1.2.2 Time Lag

Once an IT has been adopted, there may be a lapse of time before any impact (positive or not) is felt, that is, the effect of IT may not be immediate. According to Brynjolfsson (1993), surveyed executives expected it to take as long as five years for benefits to show results on the bottom line. One reason to explain this time lag addressed by Brynjolfsson (1993) and Allen (1997) deals with the extent of time that it may take users to become familiar and then proficient with a particular IT. It would only be after proficiency is achieved that benefits should be measured. Furthermore, new IT becomes available every two years, making human capital invested in earlier IT obsolete or depreciated. This requires new training and human capital development, which is a rather long-term process. As a result, if only short-term costs and benefits are taken into account, IT investments may appear to be void of any beneficial effects. Similarly, a study conducted by Kivijärvi and Saarinen (1995) reports that investments in IT do not necessarily lead to increases in a firm's financial performance. Rather, such investments are associated with long-term payoffs; this is due to the lengthy period needed to fully take advantage of newly implemented IT.

1.2.3 Redistribution and Dissipation of Profits

Another reason offered to explain the productivity paradox suggests that though IT may be beneficial to individual firms, the rate at which the industry as a whole feels the positive effects is too slow for any improvements to be recorded (Allen, 1997). In other words, IT may add value to a firm's market research or sales promotion department; this, however, does not add any value to a firm's total output. In the end, it is an issue of redistribution of, not of an increase in, benefits (Brynjolfsson, 1993). In furthering this train of thought, Allen (1997), and Brynjolfsson and Hitt (1998) also address the issue that investments in IT still represent only a small fraction of a firm's total capital stock. As a result, aggregate productivity is only minimally impacted while individual firms may experience significant productivity growth.

1.2.4 Mismanagement

The issue of mismanagement is another explanation offered by Brynjolfsson (1993) for the productivity paradox. This reasoning maintains that IT does not contribute to a firm's growth in productivity despite the tendency of top managers to continue to invest in IT. Investments are made not in the interest of the firm; rather decisions are made without up-to-date information, inefficient systems are built, and organisational slack, instead of outputs and inputs, is increased[1]. However, if managers continue to invest in IT, they must somehow believe or feel that they are getting some benefit. The issue then becomes one of measurement: if some benefit is being incurred from investments in IT, what is the most efficient and effective means to measure these benefits?

1.3 Strassmann's research

That a relationship between computer budgets and a firm's financial performance exists is one of the most widely believed fallacies, according to Paul A. Strassmann (1996) who has served as Chief Information Officer of major organizations including Xerox Corp. for 23 years, since 1961. As such, he was often asked to justify the IT budgets and

[1] This is consistent with Jensen's (1986, 1989) argument that when firms have high free cash flow (i.e., cash flow in excess of what is needed to fund positive net-present-value (NPV) projects and that is not paid out in dividends) and low growth opportunities, there is conflict of interest between managers and shareholders. Managers of such firms act opportunistically by overinvesting and misusing funds, and engage in 'value destroying activities'. Instead of paying out dividends, managers tend to invest in negative NPV projects. This is also consistent with Kocherlakota's (1996) theory of relative consumption in which he argues that managers will invest in IT only because other firms do; this is termed "keeping up with the Joneses."

expenditures by providing evidence that they were directly related to improved financial results. This need for expense justification is a very common requirement of senior IT executives: any request for funds must always be substantiated by a justification of the investment (Peet, 1998). In his search for such proof, he became sceptical about the relationship between investments in computers and a firm's profitability; he spent many years collecting data on firms' computer budgets and investments, and their financial performance; his findings supported that there exists no correlation between a firm's expenditure on computers and its financial performance (Computerworld, February 19, 1996).

While Strassmann's research fails to indicate a direct relationship between IT investments and a firm's financial performance, and he clearly states that he does not believe that computers are an "unqualified blessing" (Computerworld, February 19, 1996, p.72), he however treats computers simply as catalysts. Investments in IT in a mismanaged firm, for example, will not bring about a miracle; however in a well-managed firm run by organized, knowledgeable and motivated employees the investment in and implementation of computer and information systems can contribute to the successful performance of the firm (Computerworld, February 19, 1996, p.72). The information provided by computers is only as useful insofar as the user knows what to do with it; while computerization is not a panacea, its implementation can lead to management being more effective and employees more productive.

In order to be able to assess whether a firm has improved in it use of information, it is necessary to measure its information productivity. Strassmann calculates a firm's IPI by using figures taken from financial statements, more precisely income statements and balance sheets. The following chapter looks in detail at Strassmann's IPI, and how it is measured.

CHAPTER II

Strassmann's Information Productivity Index

"It's not technology; it's how you manage technology that will improve your company's information productivity"

After unsuccessfully trying to demonstrate that a firm's expenditure on information technology is simply and directly related to a firm's financial performance, and coming to the realization that traditional measures of productivity do not truly capture what they set out to, Strassmann developed the Information Productivity Index (IPI) which, according to him, measures the effectiveness of corporate management (Strassmann, 1994). Strassmann argues that the more common measures of productivity that only take into account expenses on IT, for example, the number of computer installations and equipment or a firm's computer budget, do not actually measure a firm's effectiveness at using its information technologies but rather how much was spent on various ITs. A firm's productivity stems not from the extent of its expenditures on IT but on its ability to use the IT in such a manner as to "support business missions and contribute to productivity" (Strassmann, 1994).

Ratios such as Return on Assets (ROA), Return on Equity (ROE), and Return on Investments (ROI) measure the efficiency of a firm's capital. Although, in the past, such ratios were good indicators of a firm's performance, in high technology and service businesses, using quantitative data does not provide a complete picture as, increasingly, quality and customer service are very much part of the equation (Wysocki & DeMichiell, p.168). A firm's productivity is becoming more and more dependent on the ability and efforts of information-enabled managers, and less influenced by the business' assets (Strassmann, 1994; Wysocki & DeMichiell, p.169).

According to Strassmann (1996), while computers can play an important role in a firm's productivity, they are nonetheless still only catalysts. What really matters is that those who are working with the computers and the information provided are knowledgeable, well-organized, motivated individuals who understand the information that is being presented to them. Essentially, Strassmann (1994) argues that technology itself is not productive; highly skilled, well-managed and motivated employees are able to provide high levels of output, with or without computers. In order to bring into perspective the importance of management, it is noteworthy to mention that the 25% of a firm's revenues that is spent on management to run the firm, coordinate suppliers and influence customers is essentially the lifeline of the firm. In contrast, less than 10% of that cost is spent on computerisation (Strassmann, 1996a) Why is it then, that so much emphasis is placed on IT budgets and expenditures rather than on management and its role in the effective functioning of the firm? The role of computers and IT is one of enabler; through IT, well-managed, trained, knowledgeable individuals are able to more effectively run the firm.

Although in the previous chapter, we defined the notion of productivity in its traditional sense, productivity can realistically not be measured as simply a ratio of input to output. According to Wysocki & DeMichiell, the analysis and measurement of productivity no longer focuses on efficiency but rather on effectiveness; this is due to the effects of new and emerging technologies, economies of scale, decentralized decision making and an emphasis on tangible as well as intangible value-added concepts. Increasingly, to capture a firm's productivity, the focus of analysis must be shifted to management's role, and new management techniques that come about as a result of diverse workforces with new skill requirements that function under new organisational structures. Information productive firms do not solely concentrate on their computer/technology power but regard all the different areas of the firm (i.e., marketing, administration, production, research) as equally important components to the firm's successful performance. Productivity therefore, is the result of "cooperation, integration, learned, shared accumulation of knowledge and clarity of goals and objectives" (Strassmann, 1995). A firm's performance depends on the proper functioning of all the parts of the larger whole; the firm is only as strong as its weakest component. Over-emphasizing one area, for example IT, does not ensure a strengthening of the whole firm. In fact, placing too much focus on one area may be more conducive to deterioration of the firm than enhancement. What is required is proper balance among all the different areas and divisions of the business (Strassmann, 1995).

Unlike traditional ratios, Strassmann's IPI takes into account and measures the effectiveness of corporate management. The following section examines in detail the formula to calculate Strassmann's IPI and the rationale used in developing such a ratio.

2.1. How Strassmann's IPI is calculated

In order to capture a firm's productivity, Strassmann argues against using revenue, profits, costs per employee, and the value of assets as either inputs or outputs in the calculation of a firm's productivity. According to Strassmann (1994), because revenues include the value-added of suppliers they should not be used as output; using profits as an indicator of performance is misleading as there is no provision for the compensation to shareholders; costs per employee do not exclude the value of purchases; and finally, the figures for the value of assets are inaccurate due to the effects of leasing and outsourcing (Strassmann, 1994).

According to Strassmann (1996b), the cost of information can no longer be equated with the costs of equity capital. Nowadays, capital is essentially a commodity; it can be borrowed, leased, outsourced and subcontracted. In most industries, information is a scarce commodity; the user of information, the company's managers, are the ones who must ensure that the information provided is used effectively in order to create business value. It is the costs of management that need to be measured since management holds a much more important stake in today's businesses than do shareholders. Increasingly, as stated by Strassmann (1996b), the capital-based industrial economy has been superseded by the managerial-dominant information economy.

Although productivity is calculated as the ratio of output to input, a measure of management's output is not readily available on a firm's income statement. However, according to Strassmann (1994), after subtracting the value of the shareholder's equity capital from after tax profits, what remains is the value of management. To calculate the return on management, Strassmann (1994) uses detailed financial information. Output is calculated by subtracting the cost of capital which has been multiplied by shareholder's equity from profit after taxes; the cost of capital is calculated as follows: Interest expenses on debt divided by (short term debt and current portion of long term debt plus long term debt). Input, that is management costs, is approximated by the selling, general and administrative expenses (SG&A). The complete formula to calculate Strassmann's IPI is therefore:

[((Profit before taxes-provision for income taxes) - (shareholder's equity*cost of capital)/SG&A]

Superior productivity is indicated by higher numbers (Strassmann, 1994).

CHAPTER III

The TSE300 Index Industries And Their Use Of Information Technology

The TSE300 Index comprises three hundred stocks from fourteen industries. This chapter reviews these fourteen industries represented on the TSE300 and discusses the extent of their use of IT, based on the literature available, both academic and practitioner. The discussion in this chapter of these industries' use of IT will form the basis of the research questions posed in the subsequent chapter. The articles and information used in the review of the industries were researched using the Proquest/ABI database; the industry name was entered and matched with the term 'information technology'(with variations such as IT, technology, computers, etc.). This method proved to be successful, with the exception of the gold and precious minerals industry, for which no match was found. Many of the articles refer to the United States; although events that are taking place in the US cannot automatically be assumed for Canada, there is a strong probability that due to the proximity of the two countries, though there may be a certain time lag, technologies that have proven effective in the US will be adopted by Canadian firms.

3.1 Metals & Minerals

Traditionally, the metals and minerals industry lagged behind in IT; however, increasingly it has been making significant investments in IT, especially in Web-based technologies and enterprise resource planning systems (ERPs) (Cone, 1998). Slight profit margins and ever-fiercer global competition have lead to the use of many emerging technologies by firms in this industry which have been forced to remain conservative mainly due to cost pressures; furthermore, after thoroughly researching the needs of customers, through surveys and buyer process mapping, firms seek the use of IT to enhance both their profitability and their customer service (Cone, 1998). Similarly, according to Pepper (1995), firms are investing in IT so as to be able to provide their employees with all the information they need to smoothly and efficiently run the business, especially in an increasingly international marketplace.

Although the metals and minerals industry is being pulled into using IT, be it in the form of the Internet or corporate intranets and that, according to Cone (1998), this industry is in the "up-and-coming category", Garcia (1996) tells of more sceptical firms that are not so quick to jump on the bandwagon. Companies first want to wait and see how much of the IT hype is trend and how much will last.

While Swarm (1998) acknowledges that applying IT to the metals and minerals industry has progressed relatively slowly, one area in which IT has recently been instrumental is in the international arena. For buyers who operate in international circles, it is extremely important for them to have access to and process information very rapidly. The way in which specifications for ferrous and non-ferrous metals are published varies across countries. As a result, it is tedious, very costly and time-consuming to cross-reference international standards, which is a necessary task to accurately determine what a particular metal contains and whether it can be used in a specific application. To tackle this problem, Eagle International Software has developed commercially available database software programs that are able to quickly and accurately cut across international standards and, through complex algorithms, calculate and cross-reference the chemical and physical properties of metals stored in the database. Before the advent of this software, to convert a foreign specification to an international standard, and to then match the chemical and physical properties to the specifications of potential end-users could take several days; with the software, the operation now takes a fraction of the time. Today, more than one thousand companies across one hundred countries are using the software. As stated by Samia Gracia Emmanuel of ISMA Steel in Monterrey, Mexico, the technology has "revolutionized the steel information industry" (Swarm, 1998).

3.2 Gold & Precious Minerals

As mentioned previously, there were no matches found when this industry's name (and variations) was entered with 'information technology'. As a result, we assume that this industry makes the least use of IT; in our analysis we use the gold and precious minerals industry as a benchmark against which all other industries are compared.

3.3 Oil & Gas

Since the price collapse in 1986, IT has assumed an important role in the oil and gas industry, a very competitive and information intensive industry (American Gas, 1996;

Carroll, 1997; Casselman, 1996). According to Philip J. Carroll, CEO of Shell Oil, who was interviewed by McWilliams (1996) "competition and information technology will alter the business for good." A firm's effective use of IT constitutes a major competitive advantage; in addition, IT helps to balance out the rising costs and risks that are associated with scarcity, to improve the performance of energy capital goods while decreasing costs, and to enhance productivity of installed assets (Walker, 1986). As reported in American Gas (1996), a study conducted by Cambridge Energy Research Associates (CERA) found that the oil and gas industry has survived and even flourished mainly due to IT since the 1986 price collapse. The CERA report finds that gas and oil companies from around the world spend close to US$6 billion annually on various information technologies such as seismic technology, horizontal drilling, graphics and futuristic visualization, networks, databases and computers. A major finding of the CERA study is that IT plays such a central role in the explorations and production business and that it is so integrated within the business that, in fact, it can no longer be considered a separate entity. In a recent Computerworld article, King (1998) examines the issue of dropping oil prices and its effect on IT; it appears that the largest oil companies have recognized the importance of IT in their industry, and thus are refraining from cost cutting in the area of IT: "cutbacks in information technology would only make a critically bad situation worse."

According to Johnston (1998), IT is being used in the oil and gas industry to increase business value while controlling costs. For the last several years, firms in this industry, as in many others, have been aiming to integrate information across the whole company, in all different departments; one of the main issues is to standardize data that may have been saved in several formats and across numerous systems (Johnston, 1998; Peebler, 1996). Other areas of information technology that are used in the oil and gas industry include "wireless communications, portable and ruggedized hardware, and software that can optimize processes and operations" (Casselman, 1996). Casselman's (1996) article discusses several technologies that are proving to be very useful in this industry, for example, hand-held devices and computers for on-site data collection at oil rigs. A more current concern is the Year 2000 problem (Johnston, 1998; King, 1998); many companies are turning to ERPs to help solve the problem.

3.4 Paper & Forest Products

In October 1997, the first International Forest Products Executive Forum was held in Pinehurst, North Carolina. The management conference's focus was on the ways that top level executives can create better value in their companies (Pulp & Paper, 1997). In one session, the transformational effects of IT were discussed; the use of IT was instrumental in changing authority structures within firms, in facilitating the transformation of companies to 'learning environments' from 'work environments', in better understanding customers' needs and in reducing the amount of redundant information within the firm (Pulp & Paper, 1997).

3.5 Consumer Products

The consumer products industry includes companies involved in food processing, tobacco, distilleries, breweries and beverages, household goods and biotechnology/ pharmaceuticals.

Due to the effects of globalization and deregulation, Canadian CEOs should expect an increased competitive environment, according to international management consulting firm A.T. Kearney (CMA Magazine, 1998). The second annual Outlook on Global Business Environment and Industry Trends identified trends, issues and developments for several industries: in the consumer products industry, Canadian companies are expected to engage in more consolidations in order to take advantage of economies of scale; also, the food industry will monitor and provide for the different demographic sectors (CMA Magazine, 1998).

The food industry is increasingly characterized by aggressive competition at all levels, namely from grocery stores, wholesalers, and suppliers. One area in which IT has become of utmost importance, according to Haines (1995), is in the relationship between wholesalers and grocery stores and suppliers. Wholesalers and grocery stores want more than ever to form relationships with suppliers who can assist them in inventory management, order replenishment, and category management; this is mainly achievable through Electronic Data Interchange (EDI) (Haines, 1995). Another technology, Efficient Customer Response (ECR), is setting up a challenge to the food and beverage industry (Gill, 1996). ECR helps monitor customers' warehouse and point-of-sale retail data and is thus able to provide better customer service with a more timely response rate. Furthermore, through ECR's monitoring abilities, food and beverage processors are able to automatically restock and supply goods in accordance with preset inventory threshold levels (Gill, 1996).

According to Harris and Hamilton (1985), for companies within the pharmaceutical industry, especially drug distributors, the use of IT in the form of electronic ordering and inventory management is crucial for survival. Often, firms that do not update their information systems lose out to their more innovative competitors who become better able to provide products and services that customers demand of them.

3.6 Industrial Products

Based on the literature, most sectors that make up the industrial products industry, i.e., transportation equipment, technology hardware and software, and auto and parts, among others, are users of IT in one form or another.

As customers are able to gather increasing amounts of information on the Internet and hence demand lower prices and better quality, the auto industry will have to become more competitive (CMA Magazine, 1998). According to Piszczalski (1997), the US auto industry was one of the first industries to adopt just-in-time manufacturing; as it is so far ahead of other industries, it has created a strategic advantage for itself. Although ERP vendors are trying to promote their packages in the auto industry, they are being challenged by this industry's far more advanced business and IT practices. Furthermore, the auto industry has long made use of EDI and is therefore much more advanced compared to other industries.

For ERP vendors to successfully provide the auto industry with what it requires will take much more powerful systems than what are currently available. The future of the auto industry will, according to Piszczalski (1997), include real time, decision support systems, data warehousing applications, multi-language, multi-currency and multi-country capabilities, systems that will evolve with the industry while taking into account the increasingly global nature.

Steelmakers make use of IT in many of their firm's activities: receiving and accepting orders, planning and scheduling facilities, operating and producing invoices, and collecting cash (Iron Age New Total, 1998). While originally, in the 1980s, the steel industry was characterized by its centralized control and operation of computing power, more recently, computers and IT are being diffused across firms and integrated in firms' strategic decision-making processes. A major barrier to total diffusion of computers and IT is CEOs' reluctance to actually get involved in and manage the technology. Often, managers fail to treat Information Systems (IS) as an integrated element of their firm; instead they regard it as 'technology silos'. For steelmakers to effectively use IT, CEOs must actively participate in ensuring that business goals drive IS decisions (Iron Age New Steel, 1998).

Mobile technology, lightweight portable computers, often equipped with flexible wireless communication abilities were designed to make doing business more efficient and effective (working from home, bringing information to all who want access to it) (Currid, 1996). In some cases, for example Compaq Computer, the manufacturer itself is using its technology to save costs, by 'relocating' field sales and support personnel from company offices to their homes. The hardware and software technology industries are also taking advantage and using IT to more effectively perform their business activities (Currid, 1996). According to Duncan, president and chief executive officer of the Information Technology Association of Canada (IRAC), the silver bullet for the information technology industry will be e-commerce (Show Preview, 1999, p.6): "E-commerce will be the next generation information highway that drives computing through the rest of the economy."

3.7 Real Estate

Though technology has been instrumental in streamlining the real estate industry, the increased amount of information available to tenants and owners have made them much more discerning groups to satisfy (Pollock, 1999). Accordingly, Feuerstein (1998) agrees that all those involved in the real estate industry, namely brokers, acquisition officers, and pension fund managers, have been affected by the Internet, extranets and intranets, which have helped to electronically link employees within a firm, data providers, and suppliers. Although Pollock (1999) argues that the real estate business will always remain a personalized business, one which cannot be entirely replaced by IT, he conceded that "technology, from communications and power requirements to HVAC needs, makes management no longer a simple, paint-and-carpet transaction. The complexity of their [tenants] needs has grown and, consequently the complexity of our job has changed" (p.40).

3.8 Transportation & Environmental Services

Although not always the case, transportation and logistics today are corporate priorities; this is mainly the case because delivery of a firm's goods is seen as a competitive/strategic tool (Harrington, 1996). Increasingly, customers are demanding better and faster service: transportation companies have no choice but to deliver.

One of the most widely used technologies in trucking equipment is communications technology; this technology enables trucks to function as mobile offices and communication nodes (Harrington, 1996). Other technologies that will soon become the norm include personal computing devices able to provide engine status and geographic position reporting and which, at the same time, allow communication between the driver and the dispatchers, shippers and emergency services.

In order to become as competitive as possible, companies are increasingly looking into intermodal transportation, one of the fastest-growing sectors of transportation. James Williams, vice-president of sales for CSX International, Hunt Valley, MD, interviewed by Harrington (1996) believes that combining different modes of transportation in the US is what will enable the country, in the long term, to remain a strong, global competitor.

3.9 Pipelines

The deregulation of the pipeline industry in 1995 has been the impetus for several firms to invest more heavily in and rely on IT. Along with EDI, automation technology offers such competitive advantages to the pipelines industry that it can no longer be ignored (Bomar, 1998a). There are four areas of innovation in automation that help to reduce operating costs while improving the efficiency, flexibility, reliability, and competitiveness of pipeline operations: new processors, distributed I/O, new interfaces, and 'ethernet'; communications (Bomar, 1998a). Scheduling and maintenance software has also been very effective at reducing costs and schedules downtime, as evidenced by Trans Canada Pipelines Ltd. (Smith, Law and Sillner, 1998).

3.10 Utilities

Dukart (1999) and Gotschall's (1998) articles on trends in the utilities industry is the basis for this section's discussion which deals with telecom, gas and electrical firms. According to Gotschall (1998), "IT is no longer regarded as a peripheral aspect of the industry, instead it is viewed as integral to the business process and a key lever for future competitiveness" (p.15).

Telecom companies will be spending their capital mainly in networks, according to Eileen Eastman, director of communications research for the Yankee Group who was interviewed by Dukart (1999). The main expenditures in gas and electrical companies are in the area of distribution systems. IT in the gas industry is increasingly being sought to upgrade customer information, materials management, and financial and human resource systems (Dukart, 1999). Furthermore, many firms, such as El Dorado, are planning to go online and are expending vast amounts of money on IT.

3.11 Communications & Media

Thanks to cable and satellite technologies, subscribers have been able to receive dozens of television channels; soon enough, television programs will be accessible via the Web (Show Preview, 1999). Accordingly, Nicholas Negroponte, director of MIT's Media Lab, states in Bolton (1997) that "the difference between a PC and a TV is the viewing experience, not the device." Negroponte argues that in the future, there will not even be a television set industry (Bolton, 1997). Though the telecommunications industry was deregulated in the US, small telcos have not vanished; there is, according to Negroponte, a place for global companies just as there is a place for small telcos: it is a question of finding a niche and exploiting it. IT is definitely helping in that area (Bolton, 1997; Clive, 1998; Janah, 1998).

Although IT is an integral part of the communications and media industry, Greiner (1997) warns that because of the extremely rapid rate of change and innovation in IT, it becomes very difficult for information professionals to keep up. Also, according to Janah (1998), because publishing, multimedia and advertising firms have a strong presence in cyberspace, are using an increased number of client/server and network applications, and are thus creating major network traffic, IT executives are faced with many new challenges and problems as they are expected to manage IT assets and set IT standards firm-wide.

3.12 Merchandising

IT is becoming such an important element in the merchandising industry that in the US, the industry is closely cooperating with colleges and universities to try to provide a sufficient number of IT professionals who will be able to ensure the future of the industry; for example, the Business Information Technology program at Florida A & M University is partly funded by Sears and trains undergraduates in retail technology (Schulz, 1998).

The main technologies used by this industry include the Internet and data warehousing (Retail I/T, 1998; Sender, 1997); technologies that are proving to be successful also include LANs, e-mail, WANs, scanners and bar coding. According to Retail I/T (1997), Stedman (1997), and Cline (1997), several technologies that have yet to be fully adopted, though in the early stages are promising, are client/server applications, computer-based training, executive information systems, expert systems, and computer-oriented ordering, among others.

3.13 Financial Services

While as little as five years ago, IT in the financial services was considered as a way of cutting corporate costs through check processing and electronic claims processing, today IT is a strategic and competitive tool that provides banks, brokerages and insurers with the means to better manage their customer relationships and to minimize risk exposure in rocky markets (Brandao, 1997; Hoffman, 1998). While presently, this industry's, as so many others', greatest concern is the year 2000 (Brandao, 1997; Hoffman, 1998; Homer, 1999;

Sales, 1998) other technologies that are becoming increasingly important include the enterprise customer information system (ECIS) which will help provide a complete view of each customer's relationship with the firm, technologies designed to improve customer retention and leverage rates (Hoffman, 1998), transaction processing software, networks/infrastructure systems (Homer, 1999), risk management systems, market data feeds, and Internet/Intranet applications (Barker, 1997; Brandao, 1997; Burger, 1997; Sales, 1998).

3.14 Conglomerates

The last industry, conglomerates, includes companies such as Canadian Pacific and Power Corp of Canada, and mainly uses IT to cut staff and increase automation (Sibley, 1997). CP rail experienced a corporate shake-up that forced it to cut costs; in order to survive with less staff and capital, the firm first implemented EDI capability and train planning tools and then installed automatic equipment identification scanners, wireless LANs and hand-held devices, and an intranet (Sibley, 1997).

Although all industries make use of various technologies to some extent, from the literature review our expectations for the fourteen industries vary. Though the metals and minerals industry has not always indulged in the use of technology, in the last few it has definitely made progress in that area. For that reason, if this industry exhibits significant results, one would expect them in the later years, say 1997 or 1998, since before that IT was not much in use.

From our arid literature review of the gold and precious minerals industry, we expect that this industry exhibit no superior use of technology. Because the oil and gas industry has been using various IT since the price collapse in 1986, we expect that this industry exhibit effective use of IT for most years. Though the paper and forest products industry is increasingly delving into the investment of IT, from our literature review, it appears that it is a rather recent phenomenon; we therefore do not expect significant positive results for this industry.

The consumer products industry encompasses so many sub-industries that it may be difficult for all these sub-industries to, all at once, exhibit effective use of their IT; it is therefore a very difficult task to predict whether results will be significant or not. Although the industrial products industry also contains several sub-industries and from our literature review we know that these sub-industries are extensive and effective users of IT, we expect that this industry report significant results. The next industry, real estate, has for a long time used technology to improve operations and gain competitive advantage. It has much experience in terms of using, becoming familiar and proficient with different technologies; we expect some significant results for this industry.

The transportation and environment services industry has just recently been investing heavily in IT; though in a few years from now we may expect to see significant results, because our research covers only the 1994 to 1998 period we do not expect to see any significant results for this industry. Similar arguments may be used in the pipelines, utilities, communications and media, and merchandising industries. For example, though deregulation of the pipelines industry occurred in 1995 and has spurred much investment in IT, we expect it still to be too early to detect any effects of these investments. Similarly, the utilities industry has started to regard IT as a necessity for survival.

The financial services industry increasingly uses IT as a strategic and competitive tool. From our literature review, this industry makes use of many different technologies. As such, we expect significant results to be reported for this industry. If, however, this is not the case, it may be explained by the industry's trend to often and quickly invest in different technologies, thus not allowing enough time to users to become familiar with the technology.

Similar to other industries, conglomerates seem to be relatively new users of IT, and this, to mainly cut staff and increase automation. As such, it is possibly still too soon to see any effects of the use of IT in this industry and the firms' effectiveness at using it.

CHAPTER IV

Research Questions

Strassmann's IPI measures how effectively a firm uses its information technology. While Strassmann's research primarily covers US industries and firms, this work extends his past research by examining Canadian firms included in the industries of the Toronto Stock Exchange 300 Index.

The three questions that this research investigates are:

1. Is there a difference in IPI among industries?

2. Is there a difference in IPI for the years included in the 1994-1998 period?

Taking into account the above two questions leads us to a third questions:

3. Does any interaction exist between industry classification and time?

The first question considers whether, with respect to IPIs, there is any industry effect, that is whether some industries more effectively use their information technology. The second question is concerned with whether time is a significant factor in firms' effective use of IT. The third question looks at whether IPIs are affected by the interaction between industry and time.

4.1 Hypotheses

Although it is safe to state that, in most industries IT is increasingly becoming a relevant factor, for some industries it is more so. While for some industries, IT has for a long time been an active and important player (e.g., real estate, oil and gas, industrial products) for others, IT is only now presenting itself as a new challenge, full of promise (e.g., metals and minerals, paper and forest products, transportation and environmental services).

As seen in the previous chapter, all industries (except gold and precious minerals) are, in some way benefiting from the use of IT. However, based on the literature available, one would expect that some industries are more prone to more effective uses of IT, which would be exhibited by statistically significantly higher IPIs. From this reasoning, the first hypothesis will be tested.

Hypothesis 1: IPIs, as calculated per Strassmann, will be significantly different from one industry to another.

Although firms in all industries invest in IT, there is a lag between the time of investment and the result (if any) brought about by the investment. In addition, as per Greiner (1997) and Janah (1998) the rapid rate of change and innovation in IT may make it very difficult for firms to keep up; in some cases, a "better, more efficient" technology may be adopted before even the previous one has had time to take effect. From the above reasoning the following hypothesis is implied.

Hypothesis 2: IPIs will be statistically significantly different across time.

While the above two hypotheses take into account industry effect and time effect each in isolation, the third research question aims to combine both effects. Essentially, what we are interested in studying is whether there exists any interaction between industry classification and time period. The third hypothesis thus states:

Hypothesis 3: The IPIs of firms in certain industries will significantly change over time.

CHAPTER V

Research Methodology

5.1 Data

The data used for the analysis was collected from multiple sources: Compustat, the Ontario Securities Commission database (SEDAR), the TSE Review journal, hard copy annual reports, and individual company's websites.

The three hundred firms listed on the TSE300 Index as at December 1998 formed the basis of our sample; data was then collected for those firms for the period 1994-1998, regardless of whether they were listed on the TSE300 Index from 1994-1997. The firms included on the TSE300 Index span the major Canadian industries, providing a well-balanced representation of the Canadian economy. Furthermore, the firms on the TSE300 Index are large-sized Canadian firms.

As seen in Chapter II, to calculate a firm's IPI, the following items taken from income statements and balance sheets are required: SG&A expenses, Profit before taxes, Provision for income taxes, Shareholder's equity, Interest expenses on debt, Short term and current portion of long term debt, and Long term debt. The number of firms for which all data was collected, and hence for which an IPI was calculated, varies from year to year. Figure 1 shows the number of observations that were collected per year.

Figure 1: Number of observations collected per year

Year	Number of observations
1994	185
1995	234
1996	258
1997	249
1998	165*
1994-1998	1091

* The data for 1998 was collected in March 1999, at which time a number of firms had not yet reported the figures to the Ontario Securities Commission. Hence, the relatively low number of observations for 1998.

5.2 Descriptive statistics

The descriptive statistics of the number of firms in each industry for the sample are provided in Appendix 1. The descriptive statistics of the IPIs used in running are provided in Appendix 2. The summary statistics of the dummy variables by time and by industry are provided in Appendices 3 and 4. Finally, Appendix 5 reports the summary statistics of dummy variables for interaction between time and industry.

5.3 Multiple regression models

5.3.1 For industry effects

$$IPI_{i,j,t} = \alpha_0^1 + \sum_{j=1}^{14} \beta_j I_{i,j,t} + \varepsilon_{i,j,t}$$

for i= 1,2,3,...117
and t= 1994, 1995, 1996, 1997, 1998
and 1994-1998

where

$IPI_{i,j,t}$ is the information productivity index for firm *i* belonging to industry *j* at time *t*

$I_{i,j,t}$ is set equal to 1 for firm *i* belonging to industry *j* at time *t* and to 0 otherwise

where for *j*,
1= metals and minerals
2= gold and precious minerals
3= oil and gas
4= paper and forest products
5= consumer products
6= industrial products
7= real estate
8= transportation and environmental services
9= pipelines
10= utilities
11= communications and media
12= merchandising
13= financial services
14= conglomerates

$\varepsilon_{i,j,t}$ is the error term for firm *I* belonging to industry *j* at time *t*

$\alpha_0{}^1$ is the regression intercept

β_j is the slope term for the *j*th industry

In this model, IPI is the dependent variable while $I_{i,j,t}$ is the independent variable. For each industry, fourteen in all, a dummy variable was created. Then, each firm was dummy variable coded, where 1 indicated that the firm was classified within that industry and 0 indicated that it was not part of that industry.

Running the regression with all fourteen industries and the regression intercept leads to perfect collinearity. To solve this problem, we drop one of the industries and make it the benchmark, against which all other industries are compared (For a more detailed discussion, see Greene (1992), chapter 16, p.464-480). When running the regression, we use industry=2 (gold and precious minerals) as the benchmark industry, and hence omit from the regression equation. Although any industry could have been made the benchmark industry, from our literature search and review, the gold and precious minerals industry appeared to be the industry in which IT was least used, whether effectively or not. The statistical significance of the βs will let us determine which industry is using IT effectively (or less effectively) relative to the benchmark industry.

We run this regression for each year (94, 95, 96, 97, 98) as well as for the combined sample (94-98), for a total of six times.

5.3.2 For time effects

$$IPI_{i,j,t} = \alpha_0^2 + \sum_{t=1}^{5} \gamma_t T_{i,j,t} + \varepsilon_{i,j,t}$$

for i=1,2,3,...,117 and j=1,2,3,...14, 1-14

where

$IPI_{i,j,t}$ is the information productivity index for firm *i* belonging to industry *j* at time *t*

$T_{i,j,t}$ is set equal to 1 for firm *i* belonging to industry *j* at time *t* and to 0 otherwise

where for t, 1= 1994
2= 1995
3= 1996
4= 1997
5= 1998

$\varepsilon_{i,j,t}$ is the error term for firm i belonging to industry j at time t

α_0^2 is the regression intercept

γ_t is the slope term for the tth year

In this model, IPI is the dependent variable while $T_{i,j,t}$ is the independent variable. For each year, five in all, a dummy variable was created. Then, each firm was dummy variable coded, where 1 indicated that the IPI was calculated for that year and 0 indicated that it was not for that year.

Running the regression with all five years and the regression intercept leads to perfect collinearity. To solve this problem, we drop one of the years and make it the benchmark, against which all other years are compared. When running the regression, we use year=1 (1994) as the benchmark year, and hence omit it from the regression equation. Although any year could have been made the benchmark year, from our literature search and review, one would expect that the longer a technology has been available, the more proficiency employees gain with it, and the more effectively firms are able to use it. Hence, we use 1994, the first year in our sample as the benchmark year. The statistical significance of the γs will let us determine in which year IT is being used more effectively (or less effectively) relative to the benchmark year.

We run this regression for each industry (1 through 14) as well as for the combined sample (1-14), for a total of fifteen times.

5.3.3 For Industry and Time effect

$$IPI_{i,j,t} = \alpha_0^3 + \sum_{j=1}^{14} \beta_j I_{i,j,t} + \sum_{t=1}^{5} \gamma_t T_{i,j,t} + \varepsilon_{i,j,t} \qquad \text{for } i=1,2,3,...117$$

where

$IPI_{i,j,t}$ is the information productivity index for firm *i* belonging to industry *j* at time *t*

$I_{i,j,t}$ is set equal to 1 for firm *i* belonging to industry *j* at time *t* and to 0 otherwise
where for *j*,
1= metals and minerals
2= gold and precious minerals
3= oil and gas
4= paper and forest products
5= consumer products
6= industrial products
7= real estate
8= transportation and environmental services
9= pipelines
10= utilities
11= communications and media
12= merchandising
13= financial services
14= conglomerates

$T_{i,j,t}$ is set equal to 1 for firm *i* belonging to industry *j* at time *t* and to 0 otherwise
where for *t*,
1= 1994
2= 1995
3= 1996
4= 1997
5= 1998

$\varepsilon_{i,j,t}$ is the error term for firm *i* belonging to industry *j* at time *t*

α_0^3 is the regression intercept

β_j is the slope term for the *j*th year

γ_t is the slope term for the *t*th year

In this model, IPI is the dependent variable while $T_{i,j,t}$ and $I_{i,j,t}$ are the independent variables. For each year, five in all, and for each industry, fourteen in all, a dummy variable was created. Then, each firm was dummy variable coded, where 1 indicated that the IPI had been calculated for that industry or year and 0 indicated that the IPI was not for that industry or year. This regression equation controls for industry and time effects simultaneously; it allows for aggregate time and industry interactions while the industry effect and time effect regressions do not.

When running the regression, we use year=1 (1994) as the benchmark year, and hence omit it from the regression equation. In order to avoid perfect collinearity, we also drop α_0^3. While we make the year 1994 the benchmark year, against which all other years are compared, we include all industries and therefore obtain absolute regression results for industries. The statistical significance of the βs and the γs will let us determine in which year, relative to the benchmark year, IT is used effectively (or less effectively), and which industries use IT more or less effectively than others, allowing for aggregate time and industry interactions.

We run this regression once for all years (1994 through 1998) and all industries (1 through 14).

5.3.4 Interaction between industry and time

$$IPI_{i,j,t} = \alpha_0^4 + \sum_{j=1}^{14} \sum_{t=1}^{5} \lambda_{i,t} IA_{i,j,t} + \varepsilon_{i,j,t} \qquad \text{for } i=1,2,3,\ldots,117$$

where

$IPI_{i,j,t}$ is the information productivity index for firm *I* belonging to industry *j* at time *t*

$IA_{i,j,t} = (I_{i,j,t} * T_{i,j,t})$

$IA_{i,j,t}$ indicates the interaction for firm *I* belonging to industry *j* at time *t*

where, for example, $IA_{1,1,1}$ indicates the interaction between firm 1 in industry 1 (metals and minerals) and time 1 (1994)

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$IA_{117,14,5}$ indicates the interaction between firm 117 in industry 14 (Conglomerates) and time 5 (1998)[2]

$\varepsilon_{i,j,t}$ is the error term for firm *I* belonging to industry *j* at time *t*

α_0^4 is the regression intercept

$\lambda_{i,t}$ is the slope term for the *i*th industry at time *t*

To calculate the $IA_{i,j,t}$, we multiply the time dummies by the industry dummies which lets us look at a firm in a given industry at a given time.

2

As there are fourteen industries and five time variables, there are a total of seventy interaction dummy variables. We hope that the two examples provided suffice to give a general idea of the definition of the interaction variables.

In this model, IPI is the dependent variable while $IA_{i,j,t}$ is the independent variable. For each interaction between industry and time, seventy in all, a dummy variable was created. Then, each firm was dummy variable coded, where 1 indicated that the firm was classified within that industry and time period and 0 indicated that it was not part of that industry and time period.

When running the regression, to track each industry over time and to avoid perfect collinearity, we omit the regression constant. The statistical significance of the λs will let us determine how an industry is using its IT over time, whether effectively or not.

We run this regression once for the combined sample of all seventy time and industry interaction dummy variables.

5.4 Estimation

We use Ordinary Least Squares (OLS) to obtain unbiased estimates of the parameters. The method of OLS is based on several statistical assumptions, namely, that the model is linear in its parameters; that the residuals are homoscedastic, i.e., that they reflect constant variance; that the residuals are not correlated with one another over time; that the independent variables and the residuals are not correlated; that the data is derived from a normally distributed population.

CHAPTER VI

Empirical Results and Analysis

This chapter reveals the results of the tests that we ran on our data, and offers our analysis of them. The softwares used in our study are Microsoft Excel and SPSS 9.0.

6.1 Industry effects

We are interested in differences across industries while holding time constant. We are testing the null hypothesis that there is no industry effect in each year, as well as in the five years, 1994-1998, taken together.

6.1.1 Year: 1994

At the 10% significance level, with 12 and 120 degrees of freedom, the F value is equal to 1.6. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no industry effect in 1994, that is that the information productivity of firms as measured by Strassmann's IPI across fourteen different industries in Canada is no different from one industry to another. Considering the t-statistics for the individual industries confirms the above; except in the case of the fourth industry, paper and forest products. This industry makes significantly better use of its IT than our benchmark industry, gold and precious minerals, with a beta coefficient of .833 at the 6.1% significant level (see table I).

Table I: 1994				
	β	t	p-value	
(Constant)	-.206	-.728	.467	
i1	-.107	-.211	.833	
i3	.433	1.243	.216	
i4	.833	1.887	.061	
i5	.564	1.186	.237	
i6	.416	1.170	.243	
i7	.836	1.065	.288	
i8	.271	.460	.646	
i9	.295	.376	.708	
i10	-5.913E-02	-.134	.894	
i11	.332	.626	.532	
i12	.297	.561	.575	
i13	.439	.973	.332	
i14	.302	.321	.749	
N=185	F: .563	Sig.: .881	R-sq. : .041	Adj. R-sq.: -.032

6.1.2 Year: 1995

At the .1% significance level, with 12 and 120 degrees of freedom, the F value is equal to 2.74. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there is industry effect in 1995, that is that the information productivity of firms as measured by Strassmann's IPI across fourteen different industries in Canada is different from one industry to another. Considering the t-statistics for the individual industries confirms the above; the metals and minerals, paper and forest products, consumer products, industrial products, utilities, communications and media, and financial services industries make significantly better use of their IT than our benchmark industry, gold and precious minerals (see table II). Compared to the previous year, industries in general are making more effective use of their IT than the gold and precious minerals industry; this is consistent with our expectations further to our reading.

Table II: 1995				
	β	t	p-value	
(Constant)	-.766	-3.361	.001	
i1	.882	2.202	.029	
i3	.456	1.579	.116	
i4	1.838	5.257	.000	
i5	.784	2.162	.032	
i6	1.004	3.608	.000	
i7	-.691	-1.280	.202	
i8	8.786E-02	.175	.861	
i9	.859	1.280	.202	
i10	.586	1.775	.077	
i11	.847	2.286	.023	
i12	.370	.894	.372	
i13	.921	2.791	.006	
i14	.629	.937	.350	
N=234	F: 3.543	Sig.: .000	R-sq: .173	Adj. R-sq.: .124

6.1.3 Year: 1996

At the .1% significance level, with 12 and 120 degrees of freedom, the F value is equal to 2.74. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there is industry effect in 1996, that is that the information productivity of firms as measured by Strassmann's IPI across fourteen different industries in Canada is different from one industry to another. Considering the t-statistics for the individual industries confirms the above for all industries, except real estate. The industries make significantly better use of their IT than our benchmark industry (see table III). Again, this is consistent with our expectations; furthermore, the seemingly apparent improvement in performance of the industries in 1996 may be explained by the time lag between the adoption of a technology and the ensuing effects. As per Brynjolfsson (1993) and Allen (1997), there is a certain extent of time during which users become familiar, then proficient, with the IT, these results could be exhibiting just that.

Table III: 1996				
	β	t	p-value	
(Constant)	-1.473	-5.868	.000	
i1	1.644	3.834	.000	
i3	1.916	6.108	.000	
i4	.870	2.220	.027	
i5	1.332	3.569	.000	
i6	1.635	5.440	.000	
i7	.461	.932	.352	
i8	1.458	2.642	.009	
i9	1.555	2.104	.036	
i10	1.218	3.393	.001	
i11	1.931	4.832	.000	
i12	1.544	3.602	.000	
i13	1.525	4.341	.000	
i14	1.802	2.763	.006	
N=258	F: 4.117	p-value: .000	R-sq.: .180	Adj. R-sq.: .136

6.1.4 Year: 1997

At the .1% significance level, with 12 and 120 degrees of freedom, the F value is equal to 2.74. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there are industry effects in 1997, that is that the information productivity of firms as measured by Strassmann's IPI across fourteen different industries in Canada is different from our benchmark industry, gold and precious minerals. Considering the t-statistics for the individual industries confirms the above for all industries (see table IV).

These results are consistent with our expectations further to our reading of the literature that all industries would make better use of their IT than the benchmark industry, gold and precious minerals.

Table IV: 1997			
	β	t	p-value
(Constant)	-2.896	-10.169	.000
i1	2.603	5.728	.000
i3	3.666	10.896	.000
i4	1.797	4.461	.000
i5	2.972	7.484	.000
i6	3.140	9.595	.000
i7	2.279	4.322	.000
i8	2.763	4.956	.000
i9	2.993	4.070	.000
i10	2.638	6.958	.000
i11	3.038	7.168	.000

Table IV: 1997				
i12	3.049	7.047	.000	
i13	3.121	8.146	.000	
i14	3.245	4.973	.000	
N=249	F: 10.983	p-value: .000	R-sq.: .378	Adj. R-sq.: .344

6.1.5 Year: 1998

At the 10% significance level, with 12 and 120 degrees of freedom, the F value is equal to 1.55. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there are no industry effects in 1998, that is that the information productivity of firms as measured by Strassmann's IPI across fourteen different industries in Canada is different from our benchmark industry, gold and precious minerals. However, when considering the t-statistics for the individual industries, several industries, namely consumer products, industrial products, transportation and environmental services, utilities, communications and media, merchandising, and financial services industries, make significantly more effective use of their IT than our benchmark industry (see table V).

Table V: 1998			
	β	t	p-value
(Constant)	-1.357	-2.182	0.031
i1	.265	.369	0.713
i3	.874	1.284	0.201
i4	1.217	1.655	0.100
i5	1.423	2.033	0.044
i6	1.502	2.302	0.023

Table V: 1998				
i7	1.394	1.468	0.144	
i8	1.645	1.972	0.050	
i9	1.402	1.476	0.142	
i10	1.341	1.902	0.059	
i11	1.479	1.942	0.054	
i12	1.260	1.713	0.089	
i13	1.165	1.703	0.091	
i14	1.145	1.063	0.289	
N=165	F: 1.241	p-value: .256	R-sq.: .097	Adj. R-sq.: .019

6.1.6 Years 1994-1998

At the .1% significance level, with 12 and ∞ degrees of freedom, the F value is equal to 2.74. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there are industry effects when taking into account all years in the time period 1994-1998, that is that the information productivity of firms as measured by Strassmann's IPI across fourteen different industries in Canada is different from our benchmark industry, gold and precious minerals. In running this regression we do not use any time dummy variables, and consider the time period 1994-1998 as one year; our sample thus includes 1091 observations and the power of regression is increased. Considering the t-statistics for the individual industries confirms the above for all industries (see table [VI]).

Table VI: 1994-1998				
	β	t	p-value	
(Constant)	-1.268	-9.567	.000	
i1	.980	4.603	.000	
i3	1.481	9.187	.000	
i4	1.231	6.297	.000	
i5	1.317	6.836	.000	
i6	1.469	9.430	.000	
i7	.587	2.124	.034	
i8	1.160	4.377	.000	
i9	1.349	3.903	.000	
i10	1.063	5.768	.000	
i11	1.470	7.054	.000	
i12	1.242	5.768	.000	
i13	1.355	7.445	.000	
i14	1.405	4.068	.000	
N=1091	F: 9.010	p-value: .000	R-sq.: .098	Adj. R-sq.: .087

To summarize this section on industry effects, it is interesting to compare the results that we obtained for the five year period, as well as for the five years taken together. While in 1994, only the paper and forest products industry showed significant results with a beta coefficient of .833 at a significance level of 6.1%, in 1995, all industries except the oil and gas, real estate, transportation and environmental services, merchandising, and conglomerates industries reported significantly different results from the benchmark industry, the gold and precious minerals industry. Only the real estate industry seems to make less effective use of its IT than the benchmark industry, while for the other industries, they make significantly better use of their IT. In 1996, only the real estate industry did not show any significant results; results of all other industries report more effective use of IT than the benchmark industry. In 1997, all industries made significantly more effective use of their IT than the gold and precious minerals industry. Finally, in 1998, except for the real estate, pipelines, and conglomerates industries, all other industries made significantly better use of their IT in 1998 than the gold and precious minerals industry. When taking into consideration all years for the time period between 1994 and 1998, all industries report more effective use of their IT than the benchmark industry. These results are consistent with our expectations, based on our literature review; we were expecting that results would reveal that industries make more effective use of their IT than the gold and precious minerals industry.

6.2 Time effects

We are interested in differences across time while holding industries constant. We are testing the null hypothesis that there is no time effect in each industry, as well as in the fourteen industries taken together.

6.2.1 Industry 1: metals and minerals

At the 10% significance level, with 4 and 60 degrees of freedom, the F value is equal to 2.04. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the metals and minerals industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above for all years (see table VII).

Table VII: Industry 1 - metals and minerals				
	β	t	p-value	
(Constant)	-0.314	-0.77	0.445	
t2	.430	0.782	0.438	
t3	.484	.898	0.373	
t4	2.041E-02	.037	0.971	
t5	-.778	-1.443	0.155	
N=55	F: 2.020	p-value: .106	R-sq.: .139	Adj. R-sq.: .070

6.2.2 Industry 2: gold and precious minerals

At the .1% significance level, with 4 and 120 degrees of freedom, the F value is equal to 4.95. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there is a time effect for the gold and precious minerals industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is different from one year to another. Considering the t-statistics for the individual years confirms the above for the years 1996 and 1997. This industry makes significantly worse use of its IT in 1996 and 1997 than in the benchmark year, 1994, with beta coefficients of -1.267 and -2.690, respectively at significance levels of less than 3% (see table VIII).

Table VIII: Industry 2 - gold and precious minerals				
	β	t	p-value	
(Constant)	-0.206	-0.52	0.605	
t2	-.560	-1.031	0.306	
t3	-1.267	-2.332	0.022	
t4	-2.690	-4.591	0.000	
t5	-1.151	-1.183	0.240	
N=87	F: 5.896	p-value: .000	R-sq.: .223	Adj. R-sq.: .185

6.2.3 Industry 3: oil and gas

At the .5% significance level, with 4 and 120 degrees of freedom, the F value is equal to 3.92. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there is time effect for the oil and gas industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is different from one year to another. Considering the t-statistics for the individual years confirms that in 1998 this industry made significantly less effective use of its IT than in 1994 (see table IX).

Table IX: Industry 3 - oil and gas				
	β	t	p-value	
(Constant)	0.227	0.947	0.345	
t2	-.537	-1.575	0.117	
t3	.216	.645	0.520	
t4	.543	1.641	0.103	
t5	-.710	-1.725	0.086	
N=181	F: 3.975	p-value: .004	R-sq.: .083	Adj. R-sq.: .062

6.2.4 Industry 4: paper and forest products

At the .1% significance level, with 4 and 60 degrees of freedom, the F value is equal to 5.31. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there is a time effect for the paper and forest products industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is different from one year to another. Considering the t-statistics for the individual years confirms the above. This industry makes significantly less effective use of its IT in 1996 and 1997 than in the benchmark year, 1994, with beta coefficients of -1.230 and -1.726, respectively (see table X).

Table X: Industry 4 - paper and forest products				
	β	t	p-value	
(Constant)	0.627	1.555	0.125	
t2	.445	.818	0.416	
t3	-1.230	-2.228	0.029	
t4	-1.726	-3.172	0.002	
t5	-.766	-1.227	0.224	
N=74	F: 5.661	p-value: .001	R-sq.: .247	Adj. R-sq.: .203

6.2.5 Industry 5: consumer products

At the 10% significance level, with 4 and 120 degrees of freedom, the F value is equal to 1.99. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the consumer products industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XI).

Table XI: Industry 5 - Consumer products				
	β	t	p-value	
(Constant)	0.358	.932	0.354	
t2	-.340	-.672	0.504	
t3	-.499	-1.034	0.305	
t4	-.282	-.579	0.565	
t5	-.292	-.577	0.566	
N=78	F: .272	p-value: .895	R-sq.: .015	Adj. R-sq.: -.039

6.2.6 Industry 6: industrial products

At the 10% significance level, with 4 and ∞ degrees of freedom, the F value is equal to 1.94. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the industrial products industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XII).

Table XII: Industry 6 - Industrial products			
	β	t	p-value
(Constant)	0.209	1.393	0.165
t2	2.803E-02	.141	0.888
t3	-4.719E-02	-.244	0.808

Table XII: Industry 6 - Industrial products				
t4	3.496E-02	.181	0.857	
t5	-6.474E-02	-.315	0.753	
N=228	F: .177	p-value: .976	R-sq.: .002	Adj. R-sq.: -.016

6.2.7 Industry 7: real estate

At the 10% significance level, with 4 and 24 degrees of freedom, the F value is equal to 2.19. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the real estate industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above except for 1995, a year during which this industry made significantly less effective use of its IT than in 1994 (see table XIII).

Table XIII: Industry 7 - real estate				
	β	t	p-value	
(Constant)	0.629	.706	0.488	
t2	-2.086	-1.850	0.078	
t3	-1.642	-1.571	0.131	
t4	-1.246	-1.170	0.255	
t5	-.592	-.470	0.644	
N=26	F: 1.113	p-value: .377	R-sq.: .175	Adj. R-sq.: .018

6.2.8 Industry 8: transportation and environmental services

At the 10% significance level, with 4 and 24 degrees of freedom, the F value is equal to 2.19. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the transportation and environmental services industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XIV).

Table XIV: Industry 8 - transportation and environmental services				
	β	t	p-value	
(Constant)	0.06479	.152	0.881	
t2	-.743	-1.232	0.230	
t3	-7.992E-02	-.132	0.896	
t4	-.198	-.328	0.746	
t5	.224	.353	0.727	
N=29	F: .680	p-value: .612	R-sq.: .102	Adj. R-sq.: -.048

6.2.9 Industry 9: pipelines

At the 10% significance level, with 4 and 10 degrees of freedom, the F value is equal to 2.61. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the pipelines industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XV).

Table XV: Industry 9 - pipelines				
	β	t	p-value	
(Constant)	0.08834	2.387	0.038	
t2	4.147E-03	.079	0.938	
t3	-6.414E-03	-.123	0.905	
t4	7.976E-03	.152	0.882	
t5	-4.314E-02	-.824	0.429	
N=15	F: .311	p-value: .864	R-sq.: .111	Adj. R-sq.: -.245

6.2.10 Industry 10: utilities

At the 10% significance level, with 4 and 120 degrees of freedom, the F value is equal to 1.99. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the utilities industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XVI).

Table XVI: Industry 10 - utilities				
	β	t	p-value	
(Constant)	-0.266	-1.055	0.294	
t2	8.496E-02	.261	0.794	
t3	1.051E-02	.033	0.974	
t4	7.794E-03	.024	0.981	
t5	.250	.702	0.485	
N=93	F: .192	p-value: .942	R-sq.: .009	Adj. R-sq.: -.036

6.2.11 Industry 11: communications and media

At the 10% significance level, with 4 and 60 degrees of freedom, the F value is equal to 2.04. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the communications and media industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XVII).

Table XVII: Industry 11 - communications and media				
	β	t	p-value	
(Constant)	0.126	.576	0.567	
t2	-4.477E-02	-.164	0.870	
t3	.332	1.230	0.224	
t4	1.594E-02	.058	0.954	
t5	-3.394E-03	-0.011	0.991	
N=59	F: .878	p-value: .483	R-sq.: .061	Adj. R-sq.: -.008

6.2.12 Industry 12: merchandising

At the 10% significance level, with 4 and 60 degrees of freedom, the F value is equal to 2.04. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the merchandising industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above, except for 1995 (see table XVIII). That year, the merchandising industry made significantly less effective use of its IT than in 1994.

Table XVIII: Industry 12 - merchandising				
	β	t	p-value	
(Constant)	0.09112	0.498	0.621	
t2	-.487	-1.984	0.053	
t3	-1.975E-02	-.084	0.934	
t4	6.139E-02	.264	0.793	
t5	-.188	-.764	0.448	
N=53	F: 1.919	p-value: .123	R-sq.: .138	Adj. R-sq.: .066

6.2.13 Industry 13: financial services

At the 10% significance level, with 4 and 120 degrees of freedom, the F value is equal to 1.99. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the financial services industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see table XIX).

Table XIX: Industry 13 - financial services				
	β	t	p-value	
(Constant)	0.233	0.905	0.368	
t2	-7.815E-02	-.239	0.812	
t3	-.181	-.566	0.573	
t4	-8.032E-03	-.025	0.980	
t5	-.424	-1.271	0.207	
N=98	F: .661	p-value: .621	R-sq.: .028	Adj. R-sq.: -.014

6.2.14 Industry 14: conglomerates

At the 10% significance level, with 4 and 10 degrees of freedom, the F value is equal to 2.61. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the conglomerates industry, that is that the information productivity of firms as measured by Strassmann's IPI for that industry is no different from one year to another. Considering the t-statistics for the individual years confirms the above (see Table XX).

Table XX: Industry 14 - conglomerates				
	β	t	p-value	
(Constant)	0.627	.292	0.776	
t2	-.233	-.553	0.593	
t3	.234	.585	0.571	
t4	.254	.635	0.540	
t5	-.307	-.666	0.520	
N=15	F: .940	p-value: .480	R-sq.: .273	Adj. R-sq.: -.017

6.2.15 Industries 1 through 14

At the 10% significance level, with 4 and ∞ degrees of freedom, the F value is equal to 1.94. Because the F-statistic is not significant, we therefore fail to reject the null hypothesis; we conclude that there is no time effect for the fourteen industries taken together, that is that the information productivity of firms as measured by Strassmann's IPI for the combined industries is no different from one year to another. In running this regression we do not use any industry dummy variables, and consider the industries 1 through 14 as one industry; our sample thus includes all observations for all industries (n=1091) and the power of regression is increased. However, considering the t-statistics for the individual years portrays a different story. When the fourteen industries are taken together, in 1996, 1997 and 1998, they make significantly less effective use of their IT than in 1994. Furthermore, with each year, the negative β coefficient become greater (see table XXI).

Table XXI: Industries 1 through 14				
	β	t	p-value	
(Constant)	0.139	1.462	0.144	
t2	-.196	-1.541	0.124	
t3	-.219	-1.759	0.079	
t4	-.236	-1.881	0.060	
t5	-.293	-2.116	0.035	
N=1091	F: 1.372	p-value: .241	R-sq.: .005	Adj. R-sq.: .001

To summarize this section on the time effects for the fourteen industries, the results for the gold and precious minerals and the paper and forest products industries reveal that significantly less effective use of IT was made during 1996 and 1997 than in 1994; the real estate and merchandising industries made significantly less effective use of their IT in 1995 than in 1994; and the oil and gas industry made significantly less effective use if its IT in 1998 than in 1994. Furthermore, when considering all industries taken together, results for 1996, 1997, and 1998 reveal that during those years, significantly less effective use of IT was made than in the benchmark year, 1994. Interestingly, all significant results reveal less effective use of IT in subsequent years compared to 1994, the benchmark year. This is contrary to our expectations, however may be explained, perhaps, by the increasing use of IT in all industries and hence, the adaptation period that users must be experiencing as they try to defeat the challenge of learning, becoming familiar, and eventually proficient with the new technologies.

6.3 Time and Industry effects

At the .1% significance level, with 15 and ∞ degrees of freedom, the F value is equal to 2.51. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there are industry or time effects for our sample across the fourteen industries for the five year period, 1994-1998. Unlike in the next regression where interaction effects are considered, in this regression the fourteen industries and the five years are examined without accounting for interaction effects. From the results in Table XXII, it is possible to report that there are industry effects for the gold and precious minerals, oil and gas, consumer products, industrial products, real estate, communications and media, and financial services industries. Furthermore, there are time effects for the five year period; during 1995, 1996, 1997, and 1998, firms made significantly less effective use of their IT than in 1994. Considering the t-statistics for the individual industries confirms the above; except for the gold and precious minerals and the real estate industry that make significantly less effective use of their technology, the other industries which report significant results make effective use of their IT.

The fact that the gold and precious minerals industry makes poor use of it technology as compared to the other industries confirms our expectations; there is practically no literature written on this industry and its use of and investment in IT. Based on the literature, this industry is not making any progress with respect to adopting and investing in IT.

Firms in the oil and gas industry make good use of their technologies and are at the forefront of adopting and investing in different IT to increase their competitive advantage. Because the price collapse occurred in 1986, this industry has had much time to experience with adopting IT to its operations; as a result, it has become familiar with the uses of several IT and has gained expertise in the field.

The industrial products industry reports effective use of technology; according to Miller and Blais (1993) firms in this industry adopt a science-based product mode of innovation, whereby there is a "high degree of technological change." Firms in this industry tend to concentrate on technical leadership through major in-house research and development. This industry's reported results may be in response to technology that was invested in in the previous years. Since top management is likely to be knowledgeable about the various technologies available, yet will only invest in those that are deemed worthwhile, it may take several years for the effects to be felt. Users are not constantly faced with the challenge of becoming familiar with new technologies.

According to Miller and Blais (1993), firms in the financial services industry adopt a "Reactive mode of reliance on information technology and process adaptation" mode of innovation. Firms in this industry are exploiters of IT; however because they are characterized by non-participative users, it takes longer for firms to actually feel the effect of newly-invested-in technologies. Firms in this industry face very strong competition from the world over and "their leaders are constantly on the lookout for new equipment." There is a high level of technological turnover; this may make it difficult to observe any consistently effective use of IT.

Table XXII: time and industry effects				
	β	t	p-value	
i1	-0.05366	-.288	0.773	
i2	-1.079	-7.040	0.000	
i3	.420	3.481	0.001	
i4	.178	1.084	0.279	
i5	.287	1.750	0.080	
i6	.432	3.675	0.000	
i7	-.448	-1.742	0.082	
i8	.109	.450	0.653	
i9	.304	.925	0.355	
i10	2.292E-02	.149	0.881	
i11	.431	2.364	0.018	
i12	.209	1.105	0.269	
i13	.325	2.145	0.032	
i14	.369	1.118	0.264	
t2	-.203	-1.667	0.096	
t3	-.234	-1.965	0.050	
t4	-.283	-2.356	0.019	
t5	-.394	-2.963	0.003	
N=1091	F: 7.197	p-value: .000	R-sq.: .108	Adj. R-sq.: .093

6.4 Time and industry interaction effects

At the .1% significance level, with 60 and ∞ degrees of freedom, the F value is equal to 1.66. Because the F-statistic is significant, we therefore reject the null hypothesis; we conclude that there are industry and time interaction effects for our sample across the fourteen industries for the five year period, 1994-1998. From the results in Table XXIII, it is possible to report that there are interaction effects for the metals and minerals industry and 1998; the gold and precious minerals industry and 1995, 1996, 1997 and 1998; the oil and gas industry and 1996, 1997, and 1998; the paper and forest products industry and 1994, 1995, 1996, and 1997; and the real estate industry and 1995 and 1996. Except for the interaction effects of time and the gold and precious minerals industry and the metals and minerals industry and 1997, the results report that effective use of IT was observed for the industries, as calculated by Strassmann's IPI. Considering the t-statistics for the individual industries confirms the above.

According to Cone (1998) the metals and minerals industry is one of the up-and-coming industries; firms are slowly and cautiously investing in ITs. As a result, it may be possible that while firms are beginning to increasingly invest in various technologies, they have not yet acquired the expertise that will enable them to be as profitable as possible. According to Swarm (1998), this industry has progressed relatively slowly in terms of applying technologies to its operations; as a result, the negative coefficient (-1.092) may simply be a step in the industry's firms learning curve. The metals and minerals industry has been slow at applying IT to its operations (Swarm, 1998); however, in the last few years, it has been making significant investments in IT. This can help explain why, when looking at the interaction effects, we observe that in 1998, when perhaps it had invested in new technology but had not yet become familiar with it, much less gained proficiency, the coefficient for this interaction is negative. Furthermore, according to Miller and Blais (1993), based on this industry's mode of innovation, it falls into the "entrepreneurial fast-track experimentation" category in which firm's "technological strategy is to develop only what is needed internally." This parallels other authors' literature that, though it may be improving, this industry is still considered as one of the more relatively lagging industries in terms of investments in IT. The negative coefficient associated with the metals and minerals industry in 1998 may be a result of the relatively cautious nature of this industry to the investment of IT. Firms in this industry are, according to Garcia (1996), less likely to invest in IT for the sake of investing; the industry as a whole has been slow to adopt different ITs, and once the firms do, it may take some time for them to use the technologies to their best advantage.

The gold and precious minerals industry seems to have made significantly less effective use of its IT in 1995, 1996, 1997 and 1998; this is in line with our expectations. As seen previously in the literature review, this industry does not seem to make much use of IT.

The significantly positive interaction effects of the oil and gas industry and 1996 and 1997 are in line with our expectations. Firms in this industry have had to invest in IT since

1986, the year of the price collapse, in order to survive in an increasingly fierce competitive environment. Because this industry has had long-term experience in dealing with integrating IT into its operations, it is known to consistently make good use of technology. In 1998, the interaction effects for the oil and gas industry are significantly negative and are again, perhaps, a sign that firms in this industry invested in new technology but have not yet become familiar with its use.

Significant results are reported for the paper and forest products, positive for 1994 and 1995, negative for 1996 and 1997. As per Miller and Blais (1993), firms in the paper and forest products industry adopt a global cost leadership mode of innovation whereby "cost leadership is achieved by the rapid modernization of plants, the acquisition of technology, process experimentation, automation, and computerization." Firms in this industry are faced with a great amount of international competition; as they do not expect real growth in volume, they shy away from capital-intensive investments in, for example, new technologies. This may help to explain that this industry made more effective use of its technologies in 1994 and 1995, yet has not taken full advantage of the newer technologies that have since emerged.

The results reported for the real estate industry and 1995 and 1996 are somewhat unexpected. The real estate industry has, for quite some time, made use of many and various technologies. The interaction effects exhibit that, perhaps, firms in this industry have not become familiar with the different technologies that are able to provide them with a competitive advantage and an increased performance of management. After all, according to Pollock (1999) the real estate industry is, and will remain, a personalized business; IT has a role to play but it may not be as great as one might expect.

Table XXIII: time and industry interaction effects			
	β	t	p-value
i1Xt1	-.314	-.790	.430
i1Xt2	.116	.324	.746
i1Xt3	.171	.496	.620
i1Xt4	-.293	-.817	.414
i1Xt5	-1.092	-3.176	.002
i2Xt1	-.206	-.775	.439
i2Xt2	-.766	-3.085	.002
i2Xt3	-1.473	-5.931	.000
i2Xt4	-2.896	-10.025	.000
i2Xt5	-1.357	-2.278	.023
i3Xt1	.227	1.189	.235
i3Xt2	-.310	-1.606	.109
i3Xt3	.443	2.380	.017
i3Xt4	.770	4.236	.000
i3Xt5	-.483	-1.812	.070
i4Xt1	.627	1.969	.049
i4Xt2	1.072	3.711	.000
i4Xt3	-.603	-2.024	.043
i4Xt4	-1.100	-3.806	.000
i4Xt5	-.140	-.371	.711
i5Xt1	.358	.996	.320
i5Xt2	1.817E-02	.059	.953
i5Xt3	-.141	-.516	.606

Table XXIII: time and industry interaction effects			
i5Xt4	7.577E-02	.270	.787
i5Xt5	6.594E-02	.214	.830
i6Xt1	.209	1.040	.299
i6Xt2	.237	1.366	.172
i6Xt3	.162	.991	.322
i6Xt4	.244	1.493	.136
i6Xt5	.145	.768	.443
i7Xt1	.629	.915	.360
i7Xt2	-1.457	-2.735	.006
i7Xt3	-1.012	-2.404	.016
i7Xt4	-.617	-1.371	.171
i7Xt5	3.734E-02	.054	.957
i8Xt1	6.479E-02	.133	.894
i8Xt2	-.678	-1.395	.163
i8Xt3	-1.514E-02	-.031	.975
i8Xt4	-.133	-.274	.784
i8Xt5	.288	.541	.588
i9Xt1	8.834E-02	.128	.898
i9Xt2	9.248E-02	.134	.893
i9Xt3	8.192E-02	.119	.905
i9Xt4	9.631E-02	.140	.889
i9Xt5	4.520E-02	.066	.948
i10Xt1	-.266	-.834	.404
i10Xt2	-.181	-.695	.487
i10Xt3	-.255	-1.004	.316
i10Xt4	-.258	-1.015	.310
i10Xt5	-1.572E-02	-.049	.961
i11Xt1	.126	.298	.766
i11Xt2	8.082E-02	.254	.800

Table XXIII: time and industry interaction effects				
i11Xt3	.458	1.488	.137	
i11Xt4	.142	.445	.657	
i11Xt5	.122	.290	.772	
i12Xt1	9.112E-02	.216	.829	
i12Xt2	-.396	-1.052	.293	
i12Xt3	7.137E-02	.208	.836	
i12Xt4	.153	.462	.644	
i12Xt5	-9.663E-02	-.257	.798	
i13Xt1	.233	.704	.481	
i13Xt2	.155	.595	.552	
i13Xt3	5.193E-02	.214	.831	
i13Xt4	.225	.864	.388	
i13Xt5	-.192	-.701	.483	
i14Xt1	9.528E-02	.113	.910	
i14Xt2	-.137	-.200	.842	
i14Xt3	.329	.553	.581	
i14Xt4	.349	.586	.558	
i14Xt5	-.212	-.252	.801	
N=1091	F: 3.810	p-value: .000	R-sq.: .207	Adj. R-sq.: .153

CHAPTER VII

Conclusion

This research has used Strassmann's Information Productivity Index (IPI) as a measure of a firm's productivity. It has considered the firms listed on the Toronto Stock Exchange 300 Index and has aimed to determine whether certain industries are more effective than others at using their technology, whether temporal effects play a significant role, and whether there exists any interaction effects between industry and time.

Certain of our findings are noteworthy, namely, that industry effects are present for all industries when taking all years into consideration, and that when looking at individual years, while for 1994 only the paper and forest products industry was reported significant, in 1996, 1997 and 1998, practically all industries reported positive significant results.

Furthermore, when looking at the time effects of the fourteen industries taken together, results report that in 1996, 1997, and 1998 industries seem to have made less effective use of their IT than in 1994. This finding was contrary to our expectations and may be as a result of the increased level of technological turnover; users are faced with the challenge of becoming familiar with new technologies, and it may take several years for the effects of the implementation of new technologies to be felt.

Finally, when looking at the time and industry interaction effects, the metals and minerals, the gold and precious minerals, and the real estate industries report negative significant results, while the oil and gas and paper and forest products industries report positive significant results for 1996 and 1997, and 1994 and 1995, respectively, and negative significant results for 1998, and 1996 and 1997, respectively.

Although this thesis only aims to determine whether some of the TSE 300 industries use their IT more effectively than others, future research will be able to use this base of information in order to examine the differences in terms of investment in, use of, adoption, or implementation of information productive industries relative to those that are less effective at using IT. As a result, future research may be able to determine the critical success factors of those industries that score higher on Strassmann's IPI, and are therefore found to be more effective in their use of IT. Also, future researchers may be interested in conducting a more controlled experiment; this could be done by observing a sample of firms held constant over several years. It would then be interesting to compare the constant to the non-constant sample and to examine the effects of new information given to the sample.

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Appendix 1: Number of firms in each industry per year						
	t=1 (1994)	t=2 (1995)	t=3 (1996)	t=4 (1997)	t=5 (1998)	All (1994-1998)
i=1: metals and minerals	9	11	12	11	12	55
i=2: gold and precious minerals	20	23	23	17	4	87
i=3: oil and gas	39	38	41	43	20	181
i=4: paper and forest products	14	17	16	17	10	74
i=5: consumer products	11	15	19	18	15	78
i=6: industrial products	35	47	53	53	40	228
i= 7: real estate	3	5	8	7	3	26
i=8: transportation and environmental services	6	6	6	6	5	29
i=9: pipelines	3	3	3	3	3	15
i=10: utilities	14	21	22	22	14	93
i=11: communications and media	8	14	15	14	8	59
i=12: merchandising	8	10	12	13	10	53
i=13: financial services	13	21	24	21	19	98
i=14: conglomerates	2	3	4	4	2	15
Total	185	234	258	249	165	1091

Appendix 2: Summary statistics of IPI by industry						
	1994	1995	1996	1997	1998	ALL
i=1	-.3138 (.5564)	.1163 (.9262)	.1707 (1.5374)	-.2934 (.9175)	-1.0921 (1.6324)	-.2878 (1.2684)
i=2	-.2064 (2.1404)	-.7661 (1.5507)	-1.4730 (1.7760)	-2.8962 (1.6546)	-1.3569 (1.3605)	-1.2677 (1.9680)
i=3	.2269 (1.4927)	-.3103 (1.2441)	.4427 (1.4655)	.7695 (1.7288)	-.4827 (1.4583)	.2135 (1.5445)
i=4	.6267 (1.6182)	1.0721 (1.2453)	-.6028 (1.6935)	-1.0996 (1.3460)	-.1397 (1.7019)	-3.70E-02 (1.6897)
i=5	.3577 (.6825)	1.817E-02 (.8741)	-.1411 (1.6011)	7.577E-02 (1.4233)	6.594E-02 (1.2643)	4.974E-02 (1.2488)
i=6	.2093 (9398)	.2374 (1.1228)	.1622 (.5469)	.2443 (.7020)	.1446 (1.0989)	.2009 (.8822)
i=7	.6293 (2.3748)	-1.4568 (1.4832)	-1.0124 (1.3199)	-.6172 (1.4240)	3.734E-02 (1.6769)	-.6809 (1.5579)
i=8	.6479E-02 (.1772)	-.6783 (1.7873)	-1.51E-02 (9.400E-02)	-.1330 (.8616)	.2884 (1.2575)	-.1079 (1.0209)
i=9	8.834E-02 (2.072E-02)	9.248E-02 (2.200E-02)	8.192E-02 (6.429E-02)	9.631E-02 (4.576E-02)	4.520E-02 (.1158)	8.085E-02 (5.745E-02)
i=10	-.2655 (1.1175)	-.1806 (.6070)	-.2550 (.9681)	-.2577 (.8055)	-1.57E-02 (1.2751)	-.2044 (.9251)
i=11	.1256 (.6690)	8.082E-02 (.2686)	.4577 (1.0401)	.1415 (.2462)	.1222 (.2723)	.2027 (.6139)
i=12	9.112E-02 (.1532)	-.3961 (.8817)	7.137E-02 (.1704)	.1525 (.4852)	-9.66E-02 (.5334)	-2.56E-02 (.5357)
i=13	.2327 (.2410)	.1546 (.6824)	5.193E-02 (.9343)	.2247 (1.0858)	-.1916 (1.2097)	8.771E-02 (.9210)
i=14	9.528E-02 (.1868)	-.1374 (.7925)	.3291 (.2103)	.3489 (.4163)	-.2119 (.4288)	.1378 (.4573)
i=1-14	.1390 (1.2475)	-5.70E-02 (1.1681	-8.02E-02 (1.2953)	-9.71E-02 (1.4493)	-.1539 (1.2554)	

[1] Mean
[2] Standard deviation

Appendix 3: Summary statistics of dummy variables by time

	1994	1995	1996	1997	1998
i=1	.1636 (.3734)	.2000 (.4037)	.2182 (.4168)	.2000 (.4037)	.2182 (.4168)
i=2	.2299 (.4232)	.2644 (.4436)	.2644 (.4436)	.1954 (.3988)	4.598E-02 (.2106)
i=3	.2155 (.4123)	.2099 (.4084)	.2265 (.4197)	.2376 (.4268)	.1105 (.3144)
i=4	.1892 (.3943)	.2297 (.4235)	.2162 (.4145)	.2297 (.4235)	.1351 (.3442)
i=5	.1410 (.3503)	.1923 (.3967)	.2436 (.4320)	.2308 (.4241)	.1923 (.3967)
i=6	.1535 (.3613)	.2061 (.4054)	.2325 (.4233)	.2325 (.4233)	.1754 (.3812)
i=7	.1154 (.3258)	.1923 (.4019)	.3077 (.4707)	.2692 (.4523)	.1154 (.3258)
i=8	.2069 (.4123)	.2069 (.4123)	.2069 (.4123)	.2069 (.4123)	.1724 (.3844)
i=9	.2000 (.4140)	.2000 (.4140)	.2000 (.4140)	.2000 (.4140)	.2000 (.4140)
i=10	.1505 (.3595)	.2258 (.4204)	.2366 (.4273)	.2366 (.4273)	.1505 (.3595)
i=11	.1356 (.3453)	.2373 (.4291)	.2542 (.4392)	.2373 (.4291)	.1356 (.3453)
i=12	.1509 (.3614)	.1887 (.3950)	.2264 (.4225)	.2453 (.4344)	.1887 (.3950)
i=13	.1327 (.3409)	.2143 (.4124)	.2449 (.4322)	.2143 (.4124)	.1939 (.3974)
i=14	.1333 (.3519)	.2000 (.4140)	.2667 (.4577)	.2667 (.4577)	.1333 (.3519)
Total (1-14)	.1696 (.3754)	.2145 (.4107)	.2365 (.4251)	.2282 (.4199)	.1512 (.3584)

[1] Mean
[2] Standard deviation

Appendix 4: Summary statistics of dummy variables by industry						
	1994	1995	1996	1997	1998	All (94-98)
i=1	4.865E-02 (.2157)	4.701E-02 (.2121)	4.651E-02 (.2110)	4.418E-02 (.2059)	7.273E-02 (.2605)	5.041E-02 (.2189)
i=2	.1081 (.3114)	9.829E-02 (.2983)	8.915E-02 (.2855)	6.827E-02 (.2527)	2.424E-02 (.1543)	7.974E-02 (.2710)
i=3	.2108 (.4090)	.1624 (.3696)	.1589 (.3663)	.1727 (.3787)	.1212 (.3274)	.1659 (.3722)
i=4	7.568E-02 (.2652)	7.265E-02 (.2601)	6.202E-02 (.2417)	6.827E-02 (.2527)	6.061E-02 (.2393)	6.783E-02 (.2516)
i=5	5.946E-02 (.2371)	6.410E-02 (.2455)	7.364E-02 (.2617)	7.229E-02 (.2595)	9.091E-02 (.2884)	7.149E-02 (.2578)
i=6	.1892 (.3927)	.2009 (.4015)	.2054 (.4048)	.2129 (.4101)	.2424 (.4299)	.2090 (.4068)
i=7	1.622E-02 (.1266)	2.137E-02 (.1449)	3.101E-02 (.1737)	2.811E-02 (.1656)	1.818E-02 (.1340)	2.383E-02 (.1526)
i=8	3.243E-02 (.1776)	2.564E-02 (.1584)	2.326E-02 (.1510)	2.410E-02 (.1537)	3.030E-02 (.1719)	2.658E-02 (.1609)
i=9	1.622E-02 (.1266)	1.282E-02 (.1127)	1.163E-02 (.1074)	1.205E-02 (.1093)	1.818E-02 (.1340)	1.375E-02 (.1165)
i=10	7.568E-02 (.2652)	8.974E-01 (.2864)	8.527E-02 (.2798)	8.835E-02 (.2844)	8.485E-02 (.2795)	8.524E-02 (.2794)
i=11	4.324E-02 (.2040)	5.983E-02 (.2377)	5.814E-02 (.2345)	5.622E-02 (.2308)	4.848E-02 (.2154)	5.408E-02 (.2263)
i=12	4.324E-02 (.2040)	4.274E-02 (.2027)	4.651E-02 (.2110)	5.221E-02 (.2229)	6.061E-02 (.2393)	4.858E-02 (.2151)
i=13	7.027E-02 (.2563)	8.974E-02 (.2864)	9.302E-02 (.2910)	8.434E-02 (.2785)	.1152 (.3202)	8.983E-02 (.2861)
i=14	1.081E-02 (.1037)	1.282E-02 (.1127)	1.550E-02 (.1238)	1.606E-02 (.1260)	1.212E-02 (.1098)	1.375E-02 (.1165)
i=1-14	.1696 (.3754)	.2145 (.4107)	.2365 (.4251)	.2282 (.4199)	.1512 (.3584)	

[1] Mean
[2] Standard deviation

Appendix 5: Summary statistics of dummy variables for interaction between time and industry					
X	t=1 (1994)	t=2 (1995)	t=3 (1996)	t=4 (1997)	t=5 (1998)
i=1	8.249E-03 (9.049E-02)	1.008E-02 (9.995E-02)	1.100E-02 (.1043)	1.008E-02 (9.995E-02)	1.100E-02 (.1043)
i=2	1.833E-02 (.1342)	2.108E-02 (.1437)	2.108E-02 (.1437)	1.558E-02 (.1239)	3.666E-03 (6.047E-02)
i=3	3.575E-02 (.1857)	3.483E-02 (.1834)	3.758E-02 (.1903)	3.941E-02 (.1947)	1.833E-02 (.1342)
i=4	1.283E-02 (.1126)	1.558E-02 (.1239)	1.467E-02 (.1203)	1.558E-02 (.1239)	9.166E-03 (9.534E-02)
i=5	1.008E-02 (9.995E-02)	1.375E-02 (.1165)	1.742E-02 (.1309)	1.650E-02 (.1274)	1.375E-02 (.1165)
i=6	3.208E-02 (.1763)	4.308E-02 (.2031)	4.858E-02 (.2151)	4.858E-02 (.2151)	3.666E-02 (.1880)
i=7	2.750E-03 (5.239E-02)	4.583E-03 (6.757E-02)	7.333E-03 (8.536E-02)	6.416E-03 (7.988E-02)	2.750E-03 (5.239E-02)
i=8	5.500E-03 (7.399E-02)	5.500E-03 (7.399E-02)	5.500E-03 (7.399E-02)	5.500E-03 (7.399E-02)	4.583E-03 (6.757E-02
i=9	2.750E-03 (5.239E-02)	2.750E-03 (5.239E-02)	2.750E-03 (5.239E-02)	2.750E-03 (5.239E-02)	2.750E-03 (5.239E-02
i=10	1.283E-02 (.1126)	1.925E-02 (.1375)	2.016E-02 (.1406)	2.016E-02 (.1406)	1.283E-02 (.1126)
i=11	7.333E-03 (8.536E-02)	1.283E-02 (.1126)	1.375E-02 (.1165)	1.283E-02 (.1126)	7.333E-03 (8.536E-02)
i=12	7.333E-03 (8.536E-02)	9.166E-03 (9.534E-02)	1.100E-02 (.1043)	1.192E-02 (.1086)	9.166E-03 (9.534E-02)
i=13	1.192E-02 (.1086)	1.925E-02 (.1375)	2.200E-02 (.1467)	1.925E-02 (.1375)	1.742E-02 (.1309)
i=14	1.833E-03 (4.280E-02)	2.750E-03 (5.239E-02)	3.666E-03 (6.047E-02)	3.666E-03 (6.047E-02)	1.833E-03 (4.280E-02)

[1] Mean
[2] Standard deviation