The Study of Risk and Returns on Investments in Information Technology

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Abstract

Information Technology (IT) investments are the largest capital budgeting item among most knowledge-and technology-intensive corporations. There is significant interest among both researchers and practitioners in understanding the relationship between IT investments and stock returns. This paper examines the role of information technology investments in asset pricing and investigates whether investments in information technology (IT) innovation can yield better stock returns on a risk-adjusted basis. Specifically, we investigate the risk and returns on the investment in IT innovations among the publicly traded investment banking companies. From an investor's perspective, can we make a better return by picking those companies that are actively engaged in IT innovations on a risk-adjusted basis? We compute the Sharpe ratio –a reward-to-risk ratio for each stock in the investment banking sector over a ten-year period from 1994 through to 2003. We adopt a multi-factor model Cahart (1997) to analyze and explain the risk and returns of the firms ranked high on IT innovations versus those firms ranked low on IT innovations. By tying the investment in IT innovations to stock market returns, we shed lights and insights on the question whether investors can gain a better return on a risk-adjusted basis by selecting those companies that are the front-runners in IT innovations.

Keywords: Information technology investment, risk and returns, investment banking

1. INTRODUCTION

Information technology has been considered as a major locomotive for economic growth for several decades. It has been widely recognized that the world economy is propelled by science and technology. We observe that information technology play a key role in shaping the whole economy and, to some extent, deciding the ups and downs of specific firms/industries. The internet that changes all human beings lives is an on going example.

Following the technology and dotcom stock bubble burst, we have witnessed the failures of more than 5000 internet businesses and a massive layoff from the IT industries. In every school and every classroom, we have seen a sharp decline in the enrollment of students majoring in information technology and systems.

Meanwhile, despite the shrinkage in the technology sector, IT investments seem to continue to grow in the real corporate world. The survivors and success stories of 21st century electronic business are most often successful brick-and mortar companies, rather than the hot internet start-ups of the late nineties (Tabor, 2005).

More ironically, electronic commerce research shows an increasing tendency for IT projects and IT strategy to be initiated outside the IT organization (Swanson, 1994). This phenomenon indicates that the current growth in IT investments may not necessarily exist in IT sectors. Rather, this growth may occur more often in non-IT sectors such as the investment banking industry.

In this paper, we focus on the IT investment in among the publicly traded investment banking companies. We analyze the risk and return relationship in IT investment from an investor's perspective.

Our main research questions are: can we make a better return by picking those companies that are actively engaged in IT innovations? What is the risk involved? Motivated by these questions, we compute the Sharpe ratio –a reward-to-risk ratio for each stock in the investment banking sector over a ten-year period from 1994 through to 2003. We adopt a multi-factor model Cahart (1997) to explain and compare the risk and returns of the firms ranked high on IT innovations versus those firms ranked low on IT innovations. We hypothesize that by investments in those firms which are IT innovators are likely to yield a better return on a risk-adjusted basis. By tying the investment in IT innovations to stock market returns, we shed lights and insights on the question whether investors can gain a better return on a risk-adjusted basis by selecting those companies that are the front runners in IT innovations.

The remainder of this study is organized as follows: Section 2 reviews the relevant literature; Section 3 describes the data, Section 4 describes the methodology; Section 5 presents the empirical results; and Section 5 concludes the paper.

2. LITERATURE REVIEW

Information Technology (IT) investments are the largest capital budgeting item among most knowledge- and technology-intensive industries and corporations. Both researchers and practitioners alike would like to gain a better understanding of the relationship between IT investments and firm performance.

However, findings to date remain mixed: while some studies find a positive relationship between IT investments and firm performance (Banker et al, 1990, Brynjolfsson and Hitt 1995, 1996; Lichtenberg 1995; Dewan and Min 1997; Bharadwaj et al. 1999, Stratopoulos and Dehning 2000), others fail to find any significant relationships at all. The earlier literature on the relation between IT and productivity finds an absence of a positive relation between spending on IT and productivity or profitability. This inconclusive result from these earlier studies is what Strassman (1990) and Loveman (1994) called "IT productivity paradox". In an age where management carefully weighs the costs and benefits of every discretionary investment dollar, finding evidence of the returns on IT investments is critical.

One possible reason for these inconclusive results may be that most studies in IS/IT literature fail to adopt the latest financial investment models and methodologies in analyzing the risk and returns relationships on IT investment.

Moreover, most earlier studies measure firm performance in terms of accounting profits and returns such as return on equity (ROE), return on assets (ROA), and return on investments (ROI). These accounting measurements capture only the snapshot of one point in time of a firm's past or existing rather than future expected cash flow. It is well-known that these accounting returns can be easily manipulated by managers via their earnings management. More importantly, the intangible value that comes with IT innovations cannot be easily captured in accounting terms. According to Alan Greenspan, Federal Reserve Board Chairman, "There are going to be a lot of problems in the future as accounting is not tracking investments in knowledge assets." (Standfield, 2005).

V. Boasson and E. Boasson (2006) find that there is a void in the previous literature to examine whether the stock market is able to capture the potential and future intangible assets associated with IT innovations, especially in a non-IT organization such as an investment bank. Very few IT/IS studies utilize financial and investment theories and models to evaluate the market valuation of IT investments. Boasson and E. Boasson's (2006) study has pioneered in adopting financial models such as Tobin's Q to measure and evaluate the stock market valuation of the firm's IT investment. They find that in terms of Tobin's Q which is the ratio of market value of a firm's assets to the replacement cost of a firm's assets, those firms that are ranked high on IT innovations outperform those firms that are ranked low on IT innovations.

However, in Boasson and Boasson's (2006) paper, they have not explored the question that is constantly facing a stock market investor: can we make a better return by picking those companies that are actively engaged in IT innovations? What is the risk involved? Thus, it is important that we extend this line of enquiry in this paper from a stock market investor's perspective by investigating the risk and return relationship in IT investments.

3. THE DATA

We select the investment banking industry to examine the risk and returns on IT investments because technological advances and technological innovations have become the key factors in this industry's development. Growing client demand for specialized investment products has led to a wide array of financial product innovations, such as various new hedging vehicles, derivative products, and specialized mutual funds. Advances in technology have lowered transaction costs and raised market efficiencies. Computers are used to calculate a firm's exposure to market movements, compute regulatory capital positions, and monitor developments in markets worldwide. Some trades are executed automatically via computer to speed market response and transaction time. To gain competitive advantage, many investment banks invest heavily in IT innovations.

However, IT innovation projects can be very difficult to manage, sometimes failing spectacularly (Financial Times, 1998) and often falling short of management expectations (Compass, 1999). Given the magnitude of IT innovation projects and their impact on a firm's operations, they can significantly affect the volatility of firm performance. Anecdotal evidence suggests that firms differ markedly in how they manage such projects and what they gain from them in return. Some firms, for example, have experienced spectacular operational and strategic benefits from IT (Kraemer, Dedrick & Yamashiro, 2000) while others have experienced equally spectacular failures (Financial Times, 1998).

In order to examine IT innovations in the investment banking industry, we collected 10 years (1994-2003) of data on IT innovations from *Compustat* and *Information Week 500* survey. *InformationWeek* provides IT-related data such as IT innovations rankings, IT budgets, number of IT employees and other IT-related information as part of an annual published survey. We use IT innovations rankings and IT budget as a proxy for IT innovations and investment. The rationale for using the data from the *InformationWeek 500* survey is that this data source has been used extensively in other similar studies (Brynjolfsson and Hitt 1996; and Lichtenberg 1995, Boasson and Boasson 2006). According to *InformationWeek*, the companies that are selected into the InformationWeek's top 500 ranking are the top companies that are distinguished by crisp and efficient technology strategies that cut costs and optimize productivity. To obtain a spot in this annual ranking of the *InformationWeek 500*, companies must demonstrate a pattern of technological, procedural, and organizational innovation. The selection process entails identifying and ranking the companies after an extensive mail, phone, and fax study. Senior IT executives are surveyed on their organizational priorities and spending plans for the year ahead.

For each year, we matched each of these 500 top IT innovative firms with its industry competitors using primarily six-digit North American Industry Classification System (NAICS) codes while using four-digit Standard Industrial Classification (SIC) codes as an additional reference.

The reason we prefer NAICS over SIC is that the SIC system was developed in the 1930's at a time when manufacturing dominated the US economic scene. Over the last 60 years, there have been numerous revisions to the SIC system, reflecting the economy's changing industrial composition. However, despite these revisions, the system has received increasing criticism about its ability to handle rapid changes in the US economy. Recent developments in information services, new forms of health care provision, expansion of services, and high tech manufacturing are examples of industrial changes that cannot be studied under the current SIC system. Developed in cooperation with Canada and Mexico, NAICS represents one of the most profound changes for statistical programs focusing on emerging economic activities. NAICS, developed using a production-oriented conceptual framework, groups establishments into industries based on the activity in which they are primarily engaged. Establishments using similar raw material inputs, similar capital equipment, and similar labor are classified in the same industry. In other words, establishments that do similar things in similar ways are classified together. Thus, NAICS provides a new tool that ensures that economic statistics reflect the nation's changing economy. (See U.S. Department of Labor, Bureau of Labor Statistics. www.bls.gov).

We extract market and accounting data from Compustat and CRSP databases, and matched yearly returns, market value, book assets, R&D, and other accounting data to these sampled firms.

After various matching and screening criteria, we are left with a clean set of 56 publicly-traded investment banking and brokerage firms over a period from 1994 through to 2003. In other words, we have a total observation of 560 firm years. To minimize the potential effect of outlier observations on the results, variables are winsorized by adjusting all values in the top and bottom percentiles to be equal to their 1st and 99th percentile values.

4. RESEARCH METHOD

To capture IT investments and innovations, we use the annual ranking data on IT innovations and IT budgets from the *InformationWeek 500*. In order to measure the stock returns in IT investments, we first compute the monthly holding period returns as follows:

$$r_j = P_t/P_{t-1} - 1 \qquad (1)$$

where

r_j= monthly returns, P_t=price at time t.

We then compute the annualized returns as follows:

$$R_j = (1+ r_j)^{12} \qquad (2)$$

where

R_j= yearly returns.

In our regression analysis of the risk and return relationship in IT investment, we adopted a factor model based on a multi-factor Carhart (1997) model specified as follows:

$$(R_{jt} - R_f) = \alpha + \beta_1 MktR_{f_{it}} + \beta_2 Smb_{it} + \beta_3 Hml_{it} + \beta_4 Umd_{it} + \varepsilon_i \qquad (3)$$

where

R_j-R_f: Excess returns over risk-free returns. Risk free returns is measured by annualized monthly treasury bills returns.

$MktR_f$: the value weighted excess return on the market portfolio

Smb: the difference in return between a small cap portfolio and a large

cap portfolio

Hml: the difference in return between a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks

Umd: the difference in return between a portfolio of past winners and a portfolio of past losers.

The rationale for using the Carhart (1997) multi-factor asset-pricing model lies in the recent literature on the cross-sectional variation of stock returns. Most mutual fund studies prior to the 90's make use of a CAPM based single index model. The intercept of such a model gives the Jensen alpha, which is usually interpreted as a measure of outperformance or under-performance relative to the market proxy. Such a CAPM based model however assumes that a fund's investment behavior can be approximated using only one single market index. Because of the wide diversity of stated investment styles, ranging from growth to small cap, it is however preferable to use a multi-factor model to account for all possible investment strategies. The studies performed by Fama & French (1992, 1993, 1996) and Chan, Jegadeesh & Lakonishok (1996) lead us to question the adequacy of a single index model to explain mutual fund performance. Therefore the Fama & French (1993) 3-factor model has been considered to give a better explanation of fund behavior. Besides a value-weighted market proxy two additional risk factors are used, size and book-to-market. Although this model already improves average CAPM pricing errors, it is not able to explain the cross-sectional variation in momentum-sorted portfolio returns. Therefore Carhart (1997) extends the Fama-French model by adding a fourth factor that captures the Jegadeesh & Titman (1993) momentum anomaly. The resulting model is consistent with a market equilibrium model with four risk factors, which can also be interpreted as a performance attribution model, where the coefficients and premia on the factor-mimicking portfolios indicate the proportion of mean return attributable to four elementary strategies.

To compare the risk-adjusted return performance, we computed a Sharpe ratio for each stock in the investment banking industry over the ten year-period of 1994-2003. The Sharpe ratio measures the expected excess returns over risk-free returns adjusted for risk. The risk in investment is computed by the standard deviation or volatility of stock returns. The Sharpe ratio is computed as follows:

$$SharpeRatio = \frac{\overline{R}_i - \overline{R}_f}{\sigma_i} \qquad (4)$$

where

R_i = Expected return of investment

R_f = The risk-free returns (annualized Treasury bills returns)

σ_i = Standard deviation of investment (volatility/risk of investment)

In order to compare stock market risk and return performance between the firms that are engaged in heavy IT innovations and their peers, we classify the sample into IT innovators and non-IT innovators and compare the two groups using independent-samples *t*-test procedure. Because this procedure can compare the mean difference between the two sample groups, it is thus appropriate to use this procedure to compare the mean difference of risk and returns performance between the IT innovating investment firms and the non-IT innovating investment firms so as to investigate whether one group outperforms the other group in terms of risk-adjusted stock returns. We conduct the cross-sectional independent-samples *t*-test for each year because we want to identify the patterns before and after internet bubble period.

After we have performed the cross-sectional independent-samples *t*-test for each year, we then conduct the time-series paired-sample t-test to compare the yearly mean values between the two groups.

A series of *t*-tests, frequency tests, and descriptive statistics were run for each year comparing the mean risk and return values between the firms high on IT investments and innovations and their respective industry peers from 1994 to 2003.

5. EMPIRICAL RESULTS

In this section, we present the empirical results for the risk and returns comparison between IT innovators and non-IT innovators among the publicly-traded investment banking companies.

Table 1 shows the empirical results for the investment industry from 1994 through to 2003. The results show that for each year the mean annualized holding period returns for the equally-weighted portfolio of the firms that are selected as IT innovators in the *InformationWeek 500* are higher than for their industry peers in each year and this mean difference is statistically significant for the years 1995, 1997, 1998, and 2000. The gap is especially large for 1997 and 1998 when the mean annualized holding period returns for the IT innovators in the investment industry are 93% in 1997 and 29% in 1998, whereas the mean annualized holding period returns for their industry peers are 33% in 1997 and -21% in 1998. These results are statistically significant with a *t*-stat of 2.3 and *p*-value of 0.03 in 1997 and a t-stat of 2.76 and p-value of 0.01 in 1998.

Table 2 shows the excess annualized holding period returns comparison between IT innovators and non-IT innovators. The results show that for each year the mean annualized *excess* holding period returns for the equally-weighted portfolio of the firms that are selected as IT innovators in the *InformationWeek 500* are higher than for their industry peers in each year and this mean difference is statistically significant for the years 1995, 1997, 2000, and 2001. The excess returns are returns after subtracting the risk-free returns. The gap is especially large for 1997 when the mean annualized excess holding period returns for the IT innovators in the investment industry are 88% in 1997 while the non-IT innovators portfolios yield an excess holding period returns of 24%. Even during the tech bubble burst year in 2000, IT innovator portfolio yields an excess returns of 14% whereas the mean annualized excess holding period returns for their industry peers is -30%.

From Table 1 and Table 2, one may notice that the results for six out of ten years are not statistically significant. However, our time-series paired sample t-tests on the yearly mean values show that the overall results are highly significant which are presented in Table 3. Table 3 shows the comparison results for the time-series of annualized holding period returns, the time-series of the yearly excess returns, and for the volatility which is measured by the standard deviations of returns fluctuations over the period of 1994-2003, and for the Sharpe ratio which is a reward-to-risk ratio or excess returns adjusted for risk. IT innovator portfolio outperforms their industry peers in terms of annualized expected returns with the mean returns of 33% versus 5.9% for the non-IT innovator portfolio. The mean difference is 27%. This result is statistically significant with a *t*-stat of 4.63 and a *p*-value of 0.001. In terms of excess returns, IT innovator portfolio has a mean excess return of 28% versus a mean excess return of 3.9% for non-IT innovators. The mean difference in the excess returns between the two portfolios is 24% and this result is statistically significant at 1 percent with a t-stat of 4.03.

In terms of return volatility or risk, IT innovator portfolio is significantly less risky than the non-IT innovator portfolio. IT innovator portfolio has a mean volatility of 56% while the non-IT innovator portfolio has a mean volatility of 135%. And this result is statistically significant with a t-stat of -2.15 and a p-value of 0.038.

In terms of Sharpe ratio, IT innovator portfolio has a mean Sharpe ratio of 0.61 while the non-IT innovator portfolio has a mean Sharpe ratio of 0.17, and the mean difference is 0.44. This result is statistically significant with a t-stat of 4.033 and a p-value of 0.001.

Table 4 shows the multi-factor regression results for the IT-innovator portfolio excess returns and the non-IT innovator portfolio excess returns. For the IT-innovator portfolio, market excess returns is positively correlated with IT-innovator portfolio excess returns and is statistically significant while other factors are not statistically significant. For the non-IT innovator portfolio, market excess returns and the small firm factor are positively correlated with non-IT innovator portfolio excess returns, while the value-stock factor is negatively correlated with the non-IT innovator portfolio excess returns. These results are statistically significant. The momentum factor is not significant for both portfolios.

Figure 1 shows graphically that the IT-innovator portfolio returns outperform the non-IT innovator portfolio returns in each year from 1994 to 2003.

Figure 2 shows graphically that in terms of annualized excess holding period returns, the IT-innovator portfolio outperforms the non-IT innovator portfolio in each year and outperforms the overall market returns in most of the years from 1994 to 2003.

Figure 3 shows graphically the risk-returns dimension of the IT-innovator portfolio, non-IT innovator portfolio, and overall market index. The x-axis represents the standard deviation or risk of stock returns while the y-axis represents the expected excess returns. It is clear that the IT-innovator portfolio outperforms the other portfolios in terms of risk and returns, while non-IT innovator portfolio is the worst in the dimension of risk and returns.

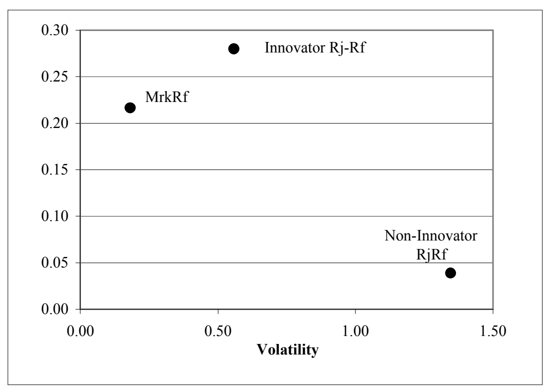

Figure 3. Risk and Return Scatter Diagram: IT Innovators, Non-IT Innovators, and Market Returns.

Overall, these results indicate that those firms engaged in IT innovations consistently outperform their industry peers in terms of the stock returns year after year on a risk-adjusted basis.

6. CONCLUSION

Our empirical results show that IT innovator portfolio outperforms the non-IT innovator portfolio and the overall market index on a risk-adjusted basis. These results are statistically significant. These findings indicate that from a stock market investor's perspective, investing in the IT innovator portfolio will yield a better risk-adjusted return than investing in the non-IT innovator portfolio. In other words, investment in information technology yields a superior risk-adjusted return for the investment banking industry.

This evidence highlights the need for our educators to motivate our students to gain knowledge of IT even for non-IT disciplines such as the finance discipline.

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Table 1. Comparison of the Annualized Stock Returns.

	IT Innovating Firms		Industry Peers		Difference		
Rj	Mean	St. Dv.	Mean	St. Dv.	MeanDiff	t-stat	p-value
1994	-0.082	0.139	-0.175	0.121	0.093	1.343	0.202
1995	0.436	0.194	0.223	0.268	0.213	1.951	0.069
1996	0.530	0.289	0.269	0.558	0.261	1.160	0.259
1997	0.929	0.684	0.334	0.585	0.594	2.295	0.030
1998	0.290	0.635	-0.213	0.354	0.503	2.762	0.010
1999	0.701	1.385	0.684	1.344	0.016	0.029	0.977
2000	0.196	0.268	-0.217	0.584	0.413	2.942	0.006
2001	0.085	0.300	-0.214	0.907	0.299	1.598	0.118
2002	-0.229	0.198	-0.355	0.396	0.126	1.338	0.192
2003	0.442	0.496	0.257	0.704	0.184	0.813	0.427

Table 2. Comparison of the Annualized Excess Stock Returns.

	IT Innovating Firm		Industry Peers		Difference		
Rj -Rf	Mean	St. Dv.	Mean	St. Dv.	MeanDiff	t-stat	p-value
1994	-0.121	0.139	-0.274	0.248	0.153	1.294	0.213
1995	0.380	0.194	0.167	0.268	0.213	1.951	0.069
1996	0.478	0.289	0.314	0.636	0.164	0.915	0.370
1997	0.876	0.685	0.235	0.583	0.641	2.566	0.016
1998	0.241	0.635	-0.067	0.820	0.308	1.116	0.282
1999	0.654	1.385	0.637	1.344	0.016	0.030	0.976
2000	0.138	0.268	-0.301	0.563	0.439	3.312	0.003
2001	0.046	0.300	-0.255	0.868	0.301	1.730	0.092
2002	-0.246	0.198	-0.372	0.396	0.126	1.336	0.193
2003	0.352	0.522	0.303	0.977	0.049	0.178	0.860

Table 3. Comparison of Expected Stock Returns, Risk, and Reward-to-Risk Sharpe Ratios.

	IT Innovating Firms		Industry Peers		Difference		
	Mean	St. Dv.	Mean	St. Dv.	MeanDiff	t-stat	p-value
Time-series Mean Rj	0.330	0.353	0.059	0.338	0.271	4.625	0.001
Time-series Mean Rj -Rf	0.280	0.344	0.039	0.340	0.241	4.028	0.003
All yrsVolatility	0.559	0.545	1.346	1.938	-0.7878	-2.151	0.038
All yrs Sharpe Ratio	0.614	0.214	0.173	0.471	0.4406	4.033	0.001

Table 4. Comparison of Multi-Factor Regression Results.

	IT Innovating Firms				**Industry Peers**			
Variables	Unst.Coef	t-stat	*p-value*	AdjR-square	Unst. Coeff	t-stat	*p-value*	AdjR-square
Constant	-0.089	-0.381	0.719	0.355	-0.136	-0.856	0.431	0.697
mktrf	1.551	2.427	0.060		0.980	2.266	0.073	
smb	0.463	0.794	0.463		1.006	2.545	0.052	
hml	-0.155	-0.276	0.793		-1.018	-2.676	0.044	
umd	-0.066	-0.161	0.878		-0.138	-0.498	0.640	
Dep Var= RjRf_innovators					**Dep Var= RjRf_non-innovators**			

Figure 1. Annualized Stock Returns Between IT innovators and Non-IT innovators

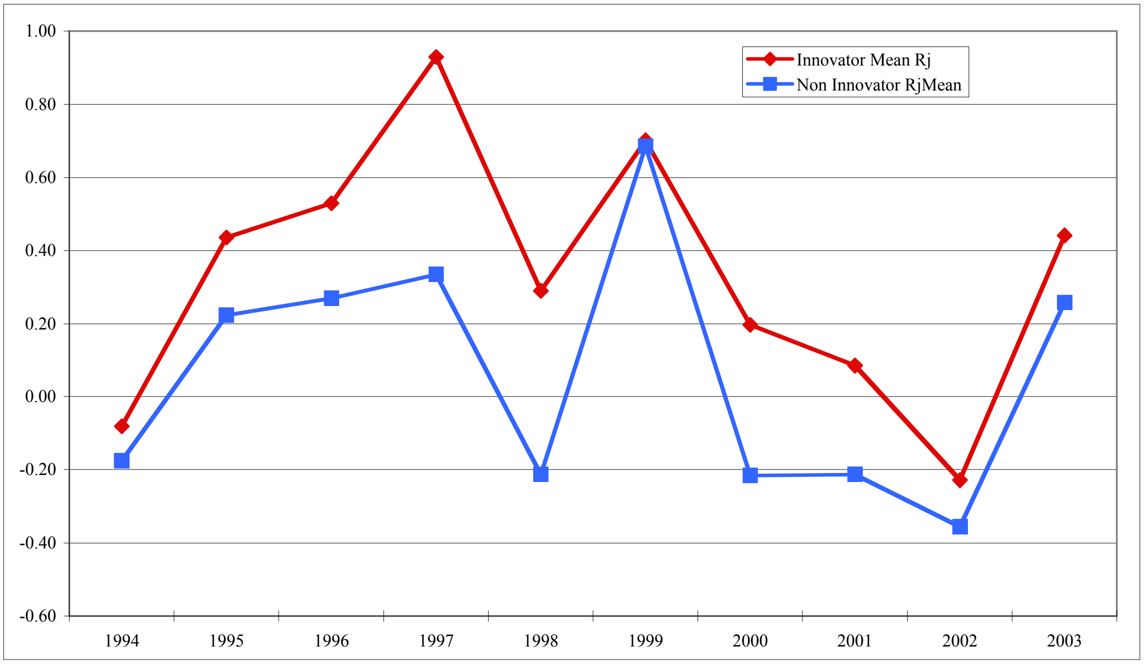

Figure 2. Comparison of Annualized Excess Stock Returns: IT Innovators, Non-IT Innovators, and Market Returns