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An Investigation of Overreaction via Implied Volatility and a Comparison between Tracking Stocks and Carve-Outs as a Restructuring Choice

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AN INVESTIGATION OF OVERREACTION VIA IMPLIED VOLATILITY AND A COMPARISON BETWEEN TRACKING STOCKS AND CARVE-OUTS AS A RESTRUCTURING CHOICE

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ABSTRACT

Chapter 1 of the dissertation investigates the firms' restructuring choice between minority carve-outs and tracking stocks using samples during 1990-2001. The extra compensation from the restructured units, the liquidity conditions, and the preservation of synergy are the significant factors determining a firm's restructuring decision. Additional compensation seems to be a major driving force behind restructuring via tracking stock. One year after the restructuring, the executive compensation of the tracking stock group increases by 241% compared to 32% for the carve-out sample. In spite of the significant increase in the compensation, the three-year buy-and-hold return for tracking stock parents is more negative than that of the carve-out parents. Thus, if the extra compensation was designed to align the interests of managers and shareholders, the goal did not materialize. The primary motive behind restructuring through carve-outs is to control the liquidity problem. Although the operating performance of the parents of either group does not improve three years after the restructuring, the long-term stock performance of carve-out parents improves when a restructured unit is less related to the parent.

Chapter 2 of the dissertation compares the degree of overreaction between value stocks and growth stocks using the implied volatility from option prices. Applying Stein's (1989) mean reversion model and Heynen, Kemna, and Vorst's (1994) GARCH and EGARCH methods, I compare the theoretical and empirical measures of reaction of long-term options in respect to short-term options for the growth and the value portfolios, which are separately classified by price-to-book and price-to-earning ratios. The evidence suggests that growth portfolios largely overreact to a greater degree than the value portfolios assuming mean reversion, GARCH, and EGARCH models. The findings potentially explain why value stocks outperform growth stocks in the long run, lending support to overreaction as an explanation for the value effect.

CHAPTER 1

FIRM'S CHOICE BETWEEN EQUITY CARVE-OUT AND TRACKING STOCK AS A RESTRUCTURING VEHICLE

I. INTRODUCTION

Three well-known forms of restructuring are spin offs, equity carve-outs, and tracking stocks. Equity carve-out is the public offering of shares of a formerly non-publicly traded subsidiary of a parent firm. Minority equity carve-out occurs when the parent carves out only a minority interest and still maintains a majority interest in the subsidiary after the restructuring. It combines characteristics of both restructuring and financing transactions as the parent sells a portion of its ownership in a subsidiary via an initial public offering (IPO). Shareholders in the new firm typically have the right to elect a board of directors, the right to vote on matters of significant importance, and a claim on the firm's net assets, though the same director might serve on the board of the parent as well as the board of the carved out subsidiary.

Tracking stock or targeted stock, in contrast, is a class of a diversified company's common stock created to track the performance of a particular business unit. Tracking stock does not represent direct ownership interest in the targeted business, but rather an ownership interest in the entire company. The shares are distributed to current shareholders on a pro-rata basis or sold through an IPO. Unlike spin-off or equity carve-out, a tracking stock does not create a new legal entity. The businesses represented by the tracking stocks remain part of the consolidated entity and share a common board of shareholders. Shareholders of a tracking stock do not elect directors to oversee management of the tracked business, nor do they have

a claim against the assets of the tracked group. A tracking stock can be issued for a business division, geographic segment, product line or any other separable business.

Spin off is vastly different from equity carve out and tracking stock due to its absolute change in control after restructuring. Spin-offs create new and distinct equity claims over the assets and result in a complete divestiture of assets by the parents. Usually the parent offers subsidiary shares to existing shareholders on a pro-rata basis. As such it does not entail new equity flows to the parent company. After restructuring, the spun-off subsidiary becomes an independent company with a separate board of directors and management team.

A carve-out unit or tracking-stock unit continues to maintain relationship with the parent firm, while a spin-off results in an independent company. In this dissertation, I attempt to answer the question as to how a firm chooses between two similar restructuring choices—carve-out vs. tracking stock. Several motives have been proposed in the literature to explain these two choices. Proponents of restructuring argue that tracking stock or equity carve-out may be used as a tool to mitigate agency problems by reducing information asymmetry and improving managerial incentives through publicly traded equity claims on a subsidiary. Prior studies of equity carve-outs and tracking stocks document a positive short-term share price reaction to the announcement of the restructuring. However, the long-term stock returns subsequent to either carve-outs or tracking stocks do not outperform the market, neither do the operating performances of the parents following the restructuring. If tracking stock and carve-out can both enable the parents to realize the proposed benefits and exhibit similar change in performance after restructuring, what factors actually differentiate the two restructuring choices and motive the managers to choose one over the other? It is important to answer this question as there might be motivations overlooked by the prior literature that mitigate the potential benefits of restructuring and may even hurt the shareholders' interests, leading to a decline in the stock and operating performance.

An important distinguishing factor between the two restructuring alternatives is that their control mechanisms are different despite of their apparent similarity. The tracking division is not a separate legal entity: typically the same board of directors manages the parent and the tracking subsidiary. In contrast, in an equity carve-out, boards and managers are separate. Tracking unit stockholders can enforce neither claims on assets nor control mechanisms, therefore there might be potential conflicts and inter-firm wealth transfers between the tracking division and the rest of the firm. Hass (1996) suggests that the shareholders of the parent firm might benefit at the expense of the shareholders of the tracking units.

While prior studies examine the stock performance of tracking stocks and carve-outs, this paper focuses on the choice between the two and uses samples over a longer period than the previous literature. The scope of this study is broader in that it examines the efficacy of corporate governance aspects, agency problems, liquidity condition, preservation of synergy, and other motives behind a firm's choice between carve-outs and tracking stocks. Another issue I address in this essay is whether the motives behind each choice achieve their intended purpose. I investigate this issue by relating restructuring choice to the long-term stock and operating performance. The findings would have implications for managers in making a restructuring choice and for investors in making investment decisions. The empirical evidence shows that firms engaging in minority carve outs need funds and intend to remain focused by carving out less-related subsidiaries. On the other hand, gaining extra compensation from tracking stocks and tracking stock options is a significant factor motivating the managers to choose tracking stocks. Although the stock and operating performances of both tracking stocks and carve-out parents deteriorate three years following the restructuring, the tracking stock group underperforms the carve-out group at the 5%

significance level. The overriding consideration of additional compensation for the tracking stock group might explain the underperformance.

The rest of the paper is organized as follows. Section two provides a detailed literature survey including the short-term and the long-term stock performance as well as the operating performance following the two forms of restructuring. Section three develops hypotheses. Section four describes the sample and research methodology. Section five presents the empirical findings and the last section concludes.

II. LITERATURE SURVEY

II.1. History of Equity Carve-outs and Tracking Stocks

Equity carve-out used to be very popular with average yearly volumes of more than $20 billion between 1995 and 2000 because of the positive shareholders' reaction. (Annema, Fallon and Goedhart, 2001). Studies found that vast majority of carve-outs ultimately lead to changes in corporate control, and very few produce significant share price increases for the parent unless the parent company follows a plan to subsequently fully separate the carved-out subsidiary.

Despite the extensive use of tracking stock structure in 1999, eight companies announced their tracking stock proposal but withdrew later in 2000. A majority of these companies are technology companies or the companies hoping to unlock the value of their internet businesses because of the decline of the information technology sector. Since then the trend to eliminate tracking stock has also spread to other non-internet businesses that have had tracking stock for a long time. For instance, Pittston, which adopted tracking stock in 1993 to provide shareholders with separate securities that would reflect its major business groups, eliminated the structure in 2000. Georgia Pacific, who used tracking stock in 1997 to separate the performance of its manufacturing and timberland businesses, received shareholder approval to sell off the targeted stock for its timber business at a special shareholders' meeting in August 2001. Cendant and Quantum also sold off the tracking divisions in early 2001. Cendant selling the business of its move.com tracking stock to homestore.com and Quantum selling the business hard disk drive tracking stock to Maxtor. Walt Disney also closed its Web portal: Go.com, eliminating its online tracking stock. Nevertheless, in 2001, Worldcom adopted the tracking stock structure intended to reflect the separate performance of its Worldcom and MCI businesses.

II.2. Short-Term Stock Performance

Prior studies find a positive stock reaction to the announcement of issuing tracking stock. Logue, Seward, and Walsh (1996), Zuta (2000), Chemmanur and Paeglis (2000), Elder and Westra (2000), D'Souza and Jacob (2000) and Haushalter and Mikkelson (2001) all report a favorable market response to firms that issued tracking stocks in recent years. Similarly, announcements of equity carve-outs produce positive stock returns for parent firms (Schipper and Smith, (1986); Anslinger at al. (1997); Allen and McConnell (1998); Vijh (2002); and Madura and Nixon (2002)). Schipper and Smith (1986) suggest that favorable returns to the parent firm from carve-outs may be attributable to a wealth transfer from bondholders as carve-outs eliminate assets of the carved-out units as collateral and shifts wealth from bondholders to shareholders. Anslinger at al. (1997) and Vijh (2002) interpret the positive average announcement effects as motivated largely by efficiency gains from the more efficient contracts between shareholders and managers and the creation of pure-play stocks. Allen and McConnell (1998) and Madura and Nixon (2002) particularly indicate that firms that pay out the proceeds from carve-out to creditors or shareholders have significantly greater abnormal returns than their counterparts that retain the proceeds.

II.3. Long-Term Performance

II.3.1. Stock performance

Researchers have investigated whether positive announcement returns are reflective of long-term performance of restructuring firms. Michaely and Shaw (1995) and Madura and Nixon (2002) find that carve-out parent firms underperform the market substantially subsequent to carve-outs. Madura and Nixon (2002) further indicate that the long-term performance of parents is more unfavorable for those that were distressed before the carve-outs. They suggest that while the carve-out serves as a source of funds for distressed firms, it

does not necessarily alleviate the distress. In addition, the carved-out units of these parents may contain a portion of the distress symptoms as well.

However, Vijh (1999) and Powers (2002) report that carve-out subsidiaries do not show significant positive or negative long-run return. Vijh (1999) finds that the newly issued subsidiary stocks do not underperform appropriate benchmarks over a three-year period following the carve-out.[1] Powers (2002) reports that the three-year stock returns of the carved-out subsidiaries are not significantly different from the returns of size and book-to-market matched comparison firms.

While Billett and Vijh (2002) and Clayton and Qian (2002) find that the parents of tracking stock firms are neutral performers, who do not significantly under- or over-perform the market, the evidence on long-term performance of tracking stocks is mixed. Chemmanur and Paeglis (2000) and Billett and Vijh (2002) find that tracking stocks generally underperform relative to industry and market benchmarks.[2] In contrast to the market indexes used in Billett and Vijh (2000) and Chemmanur and Paeglis (2000) as the benchmark, Clayton and Qian (2002) use matching samples to control for industry, book-to-market, price-to-earnings, and size, and find that tracking stocks do not significantly under- or over-perform benchmarks over the three years following the introduction. The buy-and-hold excess return of tracking stocks is positive relative to three of the four benchmarks, but insignificantly different from zero based on all the benchmarks.[3] In addition, Clayton and Qian (2002) show some evidence that the combined parent and tracking unit performance is

[1]Vijh (1999) examines the long-term excess returns of carve-outs with reference to the market portfolio and the size, book-to-market, industry, and earnings-to-price matching firms.
[2]Billett and Vijh (2000) show that tracking stocks earn negative buy-and-hold excess returns during a three-year period following the issue date. Parent firms earn significantly negative excess returns during the year before the announcement of tracking stocks.
[3]The four benchmarks in Clayton and Qian (2002) are as follows: (1) the value weighted market return from CRSP, (2) a matching sample of stocks based on industry and size, (3) a matching sample of stocks based on size and book-to-market ratio, and (4) a matching samples of stocks based on size and earnings-to-price ratio.

better relative to the benchmarks for the three years following the issuance of a tracking stock.

II.3.2. Operating performance

If the restructuring via carve-outs or tracking stocks creates value, then the firm's operating performance should improve. However, the empirical evidence on the parents of carve-out firms is inconsistent with this expectation. Powers (2003) shows that parents that carve out subsidiaries consistently underperform their matching samples and have significantly higher leverage than the matching sample. The operating performance of a carve- out subsidiary peaks at issue, and declines significantly thereafter.

Regarding the evidence on tracking stocks, Haushalter and Mikkelson (2001) find that restructuring via tracking stock does not improve operating performance of the parent, the tracking unit, or of the two units combined.[4] Loh (2001) finds that issuing firms of tracking stocks have significant underperformance prior to the issuance and continue to underperform their industry peers following the issuance, though the underperformance is smaller when compared to the pre-issuance period. The gap in profitability is especially pronounced over the one-year period just before the announcement of the issuance of the trackers.

[4] Haushalter and Mikkelson (2001) conclude that restructurings that do not relinquish control over assets would not bring about improvements in operating performance.

III. HYPOTHESES DEVELOPMENT

The similarity between tracking stock and carve-out structure and the mixed evidence of long-term stock and operating performance of the parent firms raise two questions:

"What factors actually motivate the firms to choose one over the other?" and

"Are there specific factors that lead to the changes in long term stock and operating performance?"

Proponents of tracking stock argue that tracking stock may be used as a tool to retain and recruit employees by providing compensation through stock options or bonuses that are tied to the performance or market value of the tracking stock. It also reduces the information asymmetry between managers and investors as the increasing coverage from the analysts on the tracking units allows investors to gain a better understanding of the value of business, and thereby may broaden the investor base. The carve-out structure potentially offers the parent firm similar benefits. However, as all carve-outs are initial public offerings and provide cash to the parent firms while only few issuers initially offer tracking stocks to the public, the fund-raising motive plays a strong role in carve-out decisions.

In the following section, I will review the motivations documented in the literature that could potentially give rise to value and performance increments following the carve-out and tracking stock. These motivations include corporate control and incentive considerations in terms of managerial alignment and agency issues, asymmetric information, preservation of synergy, and liquidity conditions. A contribution of the dissertation is to add another motive - corporate control and incentive issues which has been largely ignored in previous literature.

III.1. Managerial alignment motives

From a corporate governance point of view, corporate restructuring can create value for shareholders through better managerial motivation by allowing closer alignment of compensation with performance. A way to motivate divisional managers to make value-enhancing decisions is by linking their compensation to the performance of the division they manage.[5] The less related the parent and the division, the more difficult to motivate the managers based on the parent's overall performance. Zuta (2000) argues that divisional managers' performance can be better measured and accordingly compensated with the tracking stock. The improved incentive will in turn lead to improved operating performance. On the other hand, in the case of carve-out, it is less likely that the parent divisional managers are compensated with the stocks of the restructured units after the carve-out, thus the parents' motive of using carve-out as a way of aligning the divisional managers' interest with performance is weak.

I hypothesize managerial alignment motive is a major factor that leads the firm to choose tracking stock over carve-out. If tracking stock is an effective means of motivating the divisional managers, I expect a positive relationship between the managerial incentives and the performance of firms that engage in tracking stocks or carve-outs. The positive relationship will be stronger for the tracking stock firms than for the carve-out firms as the tracking unit remains intact after the restructuring.

III.2. Managerial Entrenchment

Higher agency problem for tracking-stock firms stems from the common board for the parent and the subsidiary. Harper and Madura (2002) also imply that the ultimate impact of the creation of tracking stock on shareholders depends on managerial intentions. If managers really use tracking stocks as a means to increase efficiency, then the shareholders will benefit.

[5]Schipper and Smith (1986) find that majority of the carve-out subsidiaries adopt incentive based compensation plans on the subsidiary's stock price.

If managers use it as a way of increasing their compensation for a short-term benefit, then the market will realize its true value in the long run. The managerial self-serving motives might be more severe in the case of tracking stock than that of carve-out as the same board of directors can be compensated with tracking stock related compensation. I hypothesize that the portion of executive compensation derived from the restructured unit increases significantly after the creation of tracking stock and it is a major factor influencing the firm's restructuring decision.

Tracking stock managers can better act in their self-interests if certain corporate governance aspects are met. Assuming that parent managers derive utility through private benefits of control that is an increasing function of the percentage of shares owned by the parent, proportionate holdings of tracking stocks and parent stocks would motivate mangers to maximize the market value of the combined firm, and disproportionate holdings would promote them to increase one stock price at the expense of the other. If officers own a relatively large proportion of the parent, they might be more interested in the restructuring decisions that lead to the value creation of the parent. By the same token, institutional investors are more capable monitors of firms than individual investors because they have a larger investment at stake and better access to information. Thus, the larger the institutional ownership of a parent firm the more likely it is that the parent firm will engage in performance enhancing decisions.

Other corporate governance factors such as the number of directors on the parent's board may reflect the degree of control that the board members have on the parent. Jensen (1993) suggests that the effectiveness of the board is inversely related to the number of directors as he contends that smaller boards tend to be more efficient. Madura and Nixon (2002) find that the short-term valuation effects of carve-out parents are inversely and significantly related to the board size, suggesting more favorable effects for parents overseen

by smaller numbers of board member. However, they did not make the comparison for the case between carve-out and tracking stock.

If managerial self-serving interests play a major role in the restructuring decision for tracking stock parents, then I expect to see lower insider holdings, lower monitoring role of the institutional investors, and a larger board of directors for tracking stock structure than for the carve-out structure.

III.3. Reduction of information asymmetry

One underlying reason for the existence of the agency problem is the information asymmetry problem between the shareholders and managers. It can be mitigated through increased transparency of managers' actions resulting from separate financial statements and publicly traded carve-out equity and the increased level of disclosure of the tracking units. Carve-out may function as a marketing device to increase the visibility of the parent as well as of the carve-out division. Increased visibility of the firm could lead to increased analyst coverage and higher liquidity. Schipper and Smith (1986) argue that equity carve-outs enhance the value of a firm as the separation of a subsidiary from a parent can mitigate the problem of asymmetric information between managers and investors. Over time, the reduction in asymmetric information may lead to a more accurate market perception of performance by the now independently traded units. Nanda and Narayanan (1999) and Fu (2002) show that information asymmetry between managers and investors is reduced after equity carve-outs. Measuring information asymmetry by the probability of information-based trading using a sequential trade microstructure model, Fu (2002) also shows that the reduction in information asymmetry is positively related to the abnormal returns around carve-out announcements.

A tracking stock also provides a structure to reveal more information about the restructured unit. However, the evidence related to asymmetric information theory is mixed.

While Zuta (2000) find increased analyst coverage, D'Souza and Jacob (2000) find no significant increase in the number of analysts covering firms following tracking stock issuance. Billett and Vijh (2000) also find that, for a three-year period following tracking stock creation, forecasts by analysts do not improve the transparency of firm earnings.[6] Chemmanur and Paeglis (2000) make a comparison of information asymmetry variables among tracking stocks, carve outs, and spin-offs and find some, though not significant, decline in the information asymmetry for carve-out and spin-off samples but not for the tracking stock sample. They indicate that while the number of analysts increases, there is no reduction in information asymmetry, as forecast errors increase after issuance of tracking stocks. They interpret the conflicting findings as a result of imperfect proxies for asymmetric information. In this paper, I hypothesize that firms create carve-out or tracking stock units to reduce information asymmetry.

Chemmanur and Paeglis (2000) state that the parent and subsidiaries of the tracking stock group are more related than those of the carve-out group. Assuming the information asymmetry in a more diversified firm is higher than the counterpart, I hypothesize that the information asymmetry of the carve-out parent is higher than that of tracking stock group. If the parents with high information asymmetry prior to the restructuring effectively reduce the information asymmetry after the restructuring, then their long-term stock and operating performance should improve.

III.4. Preservation of synergy

Another angle to look at the level of information asymmetry is to investigate the closeness of the parent with the restructured units. If the parent and the restructured units are closely related, the level of information asymmetry is expected to be lower than when the restructuring unit is not related. The closeness of the parent and the subsidiaries can bring

[6] Billett and Vijh (2000) examine three measures of firm transparency: the magnitude of earnings forecast errors, the dispersion of earnings forecasts across analysts, and the magnitude of market reaction to actual earnings announcements.

potential benefits described as synergies. The subsidiary may share the use of assets and enjoy the relatively low financing costs with the parent. On the other hand, the managerial and operational inefficiencies between parent and subsidiaries or the so-called negative synergies can be eliminated through restructuring and enable the parent to be focused.

Different from spin-off, in which the spun off division is a separate identity with no tie with the parent, firms engaged in carve-out or tracking stock might actually try to preserve the synergies between business units. Chemmanur and Paeglis (2000) find that the tracking stock parents and subsidiaries are more related than those of spin-offs and carve-outs. Billet and Mauer (2000) find that firms creating tracking stocks have lower diversification discounts than the matching diversified firms as measured by the excess value of a firm relative to a portfolio of industry-matched single segment firms, consistent with the view that tracking stock structure maintains positive synergy within the diversified firms.

However, the maintenance of positive synergies comes at the expense of less focusing. Carve-out is not likely to be a good option of restructuring if there are still positive operating or strategic synergies between the parent and the carved-out subsidiary. Legal protections for the public minority shareholders typically demand that all transactions with the parent company take place at fair market terms and conditions as if it were between two independent entities (Annema, Fallon, and Goedhart, 2001). This greatly reduces the flexibility and ease with which parent and the carved out subsidiaries can cooperate to capture any synergies. Since tracking stock firms retain complete control of the tracking units, I hypothesize that the tracking unit is more related to the parent than is the case for equity carve-out.

III.5. Liquidity and other motives

Other than agency related issues, the financial condition of the parent may influence the restructuring decision. Since the most obvious motive for equity offerings is to raise

external capital, an equity carve-out in this sense is comparable to an asset sale (Lang, Poulsen, and Stulz, 1995). Previous evidence shows that firms selling assets have high leverage and exhibit poor performance. Allen and McConnell (1998) and Anderson (2002)) enhance the finding by stating that parent firms are financially constrained before a carve-out offering. Furthermore, Powers (2002) finds that liquidity constrained parents as measured by low interest coverage ratio and acid test ratio sell a greater percentage of carve-out subsidiary shares and the percentage of subsidiary shares sold by parents is negatively related to subsequent changes in subsidiary operating performance as well as long-term excess return to equity. He suggests that the financing rationale plays an important role in motivating equity carve-outs. In contrast, only a small portion of tracking stocks is issued through IPO. Therefore, I hypothesize that the carve-out parents are in more immediate need for cash and their liquidity is poorer than the tracking stock counterparts.

The need for cash might be a result of higher growth or level of investment. Thus firms' choice between carve-out and tracking stock might be influenced by factors that represent operating performance such as growth opportunities and profitability of the parent firms. Loh (2001) notes that deteriorating performance, at least in part, is responsible for a firm's decision to issue tracking stock. If carve-out decision is made as to raise funds for the parent to finance past investment, the parent firm before restructuring might be highly leveraged and financially distressed but at the same time has high growth potential. If the growth potential is realized in the future, then the long-term stock performance of the carve-out firms should improve. Since the majority of tracking stock issuance is not associated with a cash flow, I hypothesize that the carve-out parents have greater growth potential and lower profitability before restructuring than the tracking stock parents.

In summary, hypotheses to be tested are as follows.

Table 1:

Hypotheses Summarized

Factors	Hypotheses
Managerial Alignment	The tracking stock parents show a stronger motive of using restructuring to align the managers' interests with performance than the carve-out parents.
Managerial Entrenchment	The executives of the tracking stock parents derive higher additional compensation from the restructured units after the restructuring than the carve-out counterpart.
	The tracking stock parents show a lower level of insider ownership than the carve-out counterparts before restructuring.
	The tracking stock parents show a lower level of institutional ownership than the carve-out counterparts before restructuring.
	The tracking stock parents show a larger board than the carve-out counterparts before restructuring.
Information Asymmetry	The carve-out parents show a higher level of information asymmetry than the tracking stock parents before restructuring.
Relatedness	The tacking stock parents are more related to the restructured subsidiaries than the carve-out counterparts.
Liquidity	The tracking stock parents have better liquidity than the carve-out counterparts before restructuring.
Growth Potential	The tracking stock parents have lower growth potential than the carve-out counterparts before restructuring.
Profitability	The tracking stock parents have higher profitability than the carve-out counterparts before restructuring.

IV. SAMPLE AND METHODOLOGY

IV.1 Sample Selection and Characteristics

My carve-out as well as tracking stock samples start from 1990 because all but two tracking stocks created before 1990.[7] The initial samples of 237 equity carve-outs and 52 tracking stocks announcements between 1990 and 2001 are derived from SDC database and cross-checked with Lexis/Nexis. For the carve-out sample, I focus on only the minority carve-outs in which the parents maintain over 50% of the ownership in the restructured units. I first delete the companies that conducted repeated carve outs and cross checked with Standard and Poor's Compustat and Center for Research in Security Prices (CRSP) to ensure there are sufficient financial statements data and executive compensation and stock data available for further analysis. This reduces the carve-out sample to 57 firms. Table 2 shows the dates of the initial public offering, ownership before and after the carve-outs for the carve-out sample.

Table 2:

Summary of Minority Equity Carve-outs for the Period of 1990 –2001

Parent Corporation Carve-outs	Carve-outs	Date	Ownership Before	Ownership After	Industry of Parent
Citicorp financial guaranty		910711	100	50.3	Insurance
Thermo electron Corp.		910724	84.4	69.7	Service
Rogers communications Inc.		910808	100	85.1	Telecom
Pier 1 imports Inc.		911004	100	60	Retail
Manor Care Inc.		920303	100	81	Healthcare
American medical technologies		920414	100	63	Sanitation
St. Paul Cos Inc.		920519	100	74	Investment Bank
Citibank NA		921216	100	82	Banking
Sears Roebuck & Co		930222	100	82.2	Wholesale
Sears Roebuck & Co		930602	100	82.1	Wholesale
Genzyme Corp.		930709	100	73	Manufacturing
TAT Technologies Ltd.		930806	94	58	Manufacturing
DUN & Bradstreet Corp.		931005	78	57	Service
Aquila Energy		931019	100	81.6	Oil/gas pipeline

[7] General Motors started two tracking stock issues in 1984

Table 2(Continued)
Summary of Minority Equity Carve-outs for the Period of 1990 –2001

Parent Corporation Carve-outs	Carve-outs	Date	Ownership Before	Ownership After	Industry of Parent
Textron Inc.		931026	100	83	Insurance
Maxco Inc.		940223	100	71.7	Wholesale
Sepracor Inc.		940325	100	57.1	Manufacturing
Sepracor Inc.		940407	100	58.0	Manufacturing
Jefferies group Inc.		940504	100	82.2	Investment Bank
ITT Corp.		941220	100	86.6	Service
AMBAC Inc.		950222	95.9	72.5	Service
American united global Inc.		950613	100	59.9	Wholesale
Medicore Inc.		960417	99.1	67	Healthcare
Du Pont		960613	100	72	Chemical
Imperial credit industries Inc.		960613	100	62.6	Securities
ThermoTrex		960627	92.3	80	Manufacturing
Elbit Ltd.		960703	78.1	59.2	Manufacturing
Capital bank		960710	100	83	Banking
National city Corp.		960808	100	87	Service
Tridex Corp.		960822	100	82.4	Manufacturing
WMS Industries		961030	100	86.8	Service
Commodore Environmental Service		970403	100	87	Manufacturing
Palomar Medical		970408	87.4	67.7	Manufacturing
Aura Systems Inc.		970915	94	75	Manufacturing
American Software Inc.		971007	100	83.7	Service
Torchmark Corp.		980304	100	89	Investment Bank
Zapata Corp.		980402	100	64.1	Agriculture
Silicon Graphics Inc.		980629	100	85.2	Manufacturing
Creative Computers Inc.		981203	100	82.3	Retail
Kushner-Locke Co.		990625	86	55.2	Service
Williams Cos Inc.		991001	100	86	Telecom
MidAmerican Energy Holdings Co.		991007	95.2	65	Real Estate
PSINet Inc.		991215	99.6	82.6	Service
AT&T Corp.		000426	100	84.4	Telecom
Northern states power Co.		000530	100	98	Electric service
SPX Corp.		000614	100	60	Natural resource
Eaton Corp.		000710	100	83.8	Manufacturing
SPX		000921	100	90.8	Manufacturing
Southern Co Inc.		000926	100	80	Electric service
MRV Communications Inc.		001109	100	92	Manufacturing
Williams Cos Inc.		001203	100	65	Oil/Gas
Titan Corp.		010315	100	84.0	Manufacturing
Lucent Technologies		010327	100	63.3	Manufacturing
Reuters Group		010517	100	87.0	Investment
Lehman Brothers Merchant		010521	84.9	59.3	Natural resource
Magna International Inc.		010731	100	80.0	Manufacturing
Millipore		010809	100	80.1	Manufacturing

For the tracking stock sample, 22 announcements never materialized. Of the remaining 30, 4 were excluded for their foreign origin. Consequently, my tracking stock sample consists of 26 firms. Table 3 summarizes the dates of creation and industry classification of the parents engaged in tracking stocks.

Table 3:
Summary of Tracking Stocks Created for the Period of 1990 -2001

Parent Corporation	Date	Industry of Parent (by two-digit SIC)
USX	910507	Primary metal industries
USX	920925	Primary metal industries
Ralston-Purina	930802	Food and kindred products
Pittston Company	930806	Coal mining
Genzyme	941216	Chemicals and allied products
CMS Energy	950721	Electric, gas, and sanitary services
US West	951101	Communication
Inco	960909	Metal mining
Circuit City Stores	970204	Automative dealers and service stations
Genzyme	981117	Chemicals and allied products
Viacom	970423	Communication
Georgia Pacific	971217	Lumber and wood products
Sprint	981124	Industrial machinery and equipment
AT&T	990310	Communication
Perkin-Elmer	991026	Instruments and related products
Ziff-Davis	990331	Printing and publishing
Quantum	990804	Industry machinery and equipment
Donaldson, Lufkin & Jenrette	990526	Security and Commodity brokers
Walt Disney	991118	Motion pictures
Genzyme	990628	Chemicals and allied products
AT&T	000427	Communication
Andrx	000907	Chemicals and allied products
Cablevision Systems	010330	Communication
Apollo	000928	Diversified services
World Com	010608	Communication
Loews	020201	Insurance

Table 4 reports the frequency of restructuring across years. Most of the tracking stocks in the sample were created in 1999, declined thereafter, while 1996 is the year in which most minority carve-outs occurred.

Table 4:
The Number of Tracking Stocks and Minority Equity Carve-outs across the Period from 1991 to 2002

Year	Tracking Stock	Minority carve-outs
1991	1	3
1992	1	4
1993	2	7
1994	1	5
1995	2	2
1996	2	9
1997	2	4
1998	2	4
1999	7	4
2000	3	8
2001	2	7
2002	1	0
Total	26	57

As one of the key hypotheses is to test whether managerial self-serving interests play a role in the restructuring decisions, I investigate the change in executive compensation after restructuring. I collected the managerial compensation data from proxy statements companies filed with SEC one year before the restructuring and one year after. Total compensation is in the form of cash compensation, stock awards, long-term investment pool (LTIP), stock options, as well as other annual compensations of the top five executives reported for each sample firm. The Long Term Investment Pool (LTIP) is a balanced fund consisting primarily of high-quality, readily marketable stocks and bonds. The primary purpose of the long-term investment pool is to promote managerial interests and the interests of shareholders by motivating key employees to work towards achieving long-range goals and by attracting and retaining exceptional employees.

The corporate governance variables such as insider holding and board composition are derived from the Compact Disclosure CD-ROM. I also extract the accounting and operating performance data from COMPUSTAT database and the stock trading data from CRSP for the period between 1990 and 2003.

IV.2. Methodology

IV.2.1 Logistic regression on restructuring choice

Binomial logistic regressions of restructuring choice are run on managerial factors, liquidity measures, information asymmetry measures, synergy measures, and other motive measures.

$$CH = c + \beta_1 BSIZE + \beta_2 DELTAC + \beta_3 THETA + \beta_4 RES + \beta_5 INS + \beta_6 INST + \beta_7 REL + \beta_8 INF + \beta_9 INT + \beta_{10} MB + \beta_{11} ROA + \varepsilon$$

Where

- CH: Restructuring choice – the dummy is 1 if the restructuring is a creation of tracking stock, 0 if it is a carve-out;
- BSIZE: Board size as a proxy for the board effectiveness;
- THETA: The percentage change in compensation to stock price changes between T_{-1} and T_{+1};
- DELTAC: The percentage change in total compensation between T_{-1} and T_{+1};
- RES: The percentage change in compensation from the restructured units relative to total compensation between T_{-1} and T_{+1};
- INS: The percentage of insider ownership in the parent;
- INST: The percentage of ownership held by institutions;
- REL: Relatedness of the subsidiary to the parent;
- INF: Absolute value of earning forecast errors, divided by earning per share;

- INT: Interest coverage ratio as a proxy for liquidity;
- MB: Market to book ratio;
- ROA: Return on assets;
- ε is the error term;
- c, β_1 - β_{11} are estimate parameters.

THETA is the managerial alignment measure. Similar to that of Haushalter and Mikkelson (2000), the managerial incentives measure in this paper is the sensitivity of CEO wealth to share price in terms of stock holdings and stock options scaled by total compensation. If compensation scheme in the form of stocks and stock options is effective, the interests of the managers can be better aligned with those of the shareholders, therefore leading to an improvement in performance. For presentation purpose, I use T_0 to represents the year when the restructuring occurs, T_{-1} to represent one year before the restructuring year, and T_{+1} to represent one year after.

$$THETA = \frac{\Delta\text{stock holdings} + \Delta\text{stock options}}{\text{cash compensation} + \text{stock holdings} + \text{stock options} + \text{LTIP} + \text{Others}}$$

Where

Δ share holdings = the change in the value of share holdings between T_{-1} and T_{+1}.

Δ stock options = the change in the value of stock options between T_{-1} and T_{+1}.

Share holdings, stock options, cash compensation, LTIP and others represent the share holdings, stock options holdings, cash compensation, long-term investment pool and other compensation of the insiders at T_{-1} respectively.

Share holdings are measured in terms of dollar amount of shares distributed to the top five executive managers as part of the compensation. Stock options are measured in terms of present value determined using the Black Scholes Option Pricing Model at the time of grant.

An alternative measure of managerial incentive, DELTAC, is the percentage change in total compensation of the executives including cash compensation, long-term investment pool, stocks, stock options and other compensation between T_{-1} and T_{+1}.

$$DELTAC = \frac{\Delta\text{cash compensation} + \Delta\text{stock holdings} + \Delta\text{stock options} + \Delta\text{LTIP} + \Delta\text{Others}}{\text{cash compensation} + \text{stock holdings} + \text{stock options} + \text{LTIP} + \text{Others}}$$

Where

Δ Cash compensation = the change in the value of cash compensation between T_{-1} and T_{+1}.

Δ LTIP= the change in the value of long-term investment pool between T_{-1} and T_{+1}.

Δ Others = the change in the value of other compensation between T_{-1} and T_{+1}.

RES is the measure of additional compensation from the restructured subsidiaries after restructuring and calculated as the percentage increase from the total compensation at T_{-1}.

$$RES = \frac{\Delta\text{subsidiary stock holdings} + \Delta\text{subsidiary stock options}}{\text{cash compensation} + \text{stock holdings} + \text{stock options} + \text{LTIP} + \text{Others}}$$

Where

Δsubsidiary stock holdings and Δsubsidiary stock options are the change in the value of executive compensation in terms of stocks or stock options of the restructured subsidiary between T_{-1} and T_{+1}.

Other corporate governance factors considered in the study include insider holding, institutional holdings and board size. BSIZE, board size, is a proxy for the board

effectiveness, measured in the number of executives on the parent's board of directors. INS, insider ownership, is the percentage ownership of all officers and directors of the parent. INST, institutional ownership, indicates the percentage ownership of the institutional investors. It can be also treated as an indirect information asymmetry measure, since a relatively large number of institutional investors can bring information to the market, therefore result in lower information asymmetry between the investors and managers.

The proxy of liquidity motive of the firm to raise external capital through restructuring is INT, the interest coverage ratio. The lower the interest coverage ratio, the worse the liquidity and the more likely the firm would use initial public offering to raise funds.

The synergy measure is the relatedness of the subsidiary to the parent, measured as the number of the first digits of four-digit SIC codes that are the same for the parent and subsidiary. If the four-digit SIC codes of the parent are exactly the same as those of the restructured unit, 4 is given. If first three SIC codes are the same, 3 is given, and vice versa.

Similar to the information asymmetry measure in Krishnaswami and Subramaniam (1999), INF, is the absolute value of the difference between latest actual quarter earning per share and actual quarter average estimate, divided by the latest actual earnings per share. It is a measure of how accurately reported quarterly earnings were anticipated by investors, represented as a percentage of actual earnings. A larger percentage indicates higher level of information asymmetry between investors and managers.

Profitability and efficiency of the parent before restructuring are also taken into account. Return on assets, ROA, is the profitability measure. Market to book ratio, MB, is the proxy for growth opportunities. In summary, the empirical proxies and the predicted relationship between the various firm motives and the restructuring choice are as follows in Table 5.

Table 5:
The Hypothesized Relationship between Restructuring Choice and All Motives

THETA is the percentage change in stock related compensation after restructuring; DELTAC is the absolute value change in compensation after restructuring; RES is the change in compensation resulted from the restructured subsidiaries after restructuring; INS is the insider holding; INST is the institutional holding; BSIZE is the board size; REL is the measure of relatedness; INT is the interest coverage ratio before tax; INF is the information asymmetry measure; MB is the price-to-book ratio, the growth measure; and ROA is the return on assets.

	Proxy	Predicted Relationship
Managerial Alignment	THETA	$THETA_T$? $THETA_C$[8]
	DELTAC	$DELTAC_T$? $DELTAC_C$[9]
Managerial Entrenchment	RES	$RES_T > RES_C$
	INS	$INS_T < INS_C$
	INST	$INST_T < INST_C$
	BSIZE	$BSIZE_T > BSIZE_C$
Information Asymmetry	INF	$INF_T < INF_C$
Synergy	REL	$REL_T > REL_C$
Liquidity	INT	$INT_T > INT_C$
Growth Potential	MB	$MB_T < MB_C$
Profitability	ROA	$ROA_T > ROA_C$

[8] ? indicates no predetermined relationship for the percentage change in total stock compensation.

[9] ? indicates no predetermined relationship for the percentage change in total compensation.

IV.2.2 Multiple Regressions of Long-Term Performance

IV.2.2.1. Stock performance

To examine long-run stock performance after the restructuring, I calculate the buy-and-hold return from purchasing shares at the closing price on the day of the restructuring to the end of the appropriate holding period.

The buy-and-hold return is defined as:

$$\text{Buy-and-Hold Return} = [\prod_{T_1}^{T_2}(1 + r_{it})]$$

Where T_1 is the date of the restructuring; T_2 is the ending date of the holding period, one year, two years and three years respectively; and r_{it} is the return for firm i on day t.

Multiple regressions of long-term buy-and-hold stock performance of parents are run on managerial factors, liquidity measures, information asymmetry measures, synergy measures, and other profitability and growth measures. I investigate one-year, two-year and three-year buy-and-hold returns for both samples to find out what motives lead to the difference in their long-term stock performance.

$$BHR = c + \beta_1 BSIZE + \beta_2 DELTAC + \beta_3 THETA + \beta_4 RES + \beta_5 INS + \beta_6 INST + \beta_7 REL + \beta_8 INF + \beta_9 INT + \beta_{10} MB + \beta_{11} ROA + \varepsilon$$

Where BHR is the buy-and-hold stock return.

IV.2.2.2. Operating performance

If the restructuring decision helps the parent firm better motivate the managers to increase productivity and achieve efficiency, then there should be an improvement in the firm's operating performance. I test this hypothesis by regressing the changes in the operating performance three years following the restructuring on the above mentioned motives to see whether the change in operating performance is attributed to certain motives.

$$\Delta ROA = c + \beta_1 BSIZE + \beta_2 DELTAC + \beta_3 THETA + \beta_4 RES + \beta_5 INS + \beta_6 INST + \beta_7 REL + \beta_8 INF + \beta_9 INT + \beta_{10} MB + \beta_{11} ROA + \varepsilon$$

Where Δ ROA is the change in return on assets at T_{+3} comparing to that of $T_{0,}$ a measure of operating efficiency.

IV.2.3. Sample Decomposition

I also examine whether similar results hold for each subgroup of firms that issue tracking stocks or carve-outs. Parent companies generally gain control of a subsidiary when the ownership percentage exceeds 50%. However, the financial statements of the parent and subsidiaries are consolidated for tax purposes when the parent owns over 80% of the ownership. Tax consolidation is a benefit if operating losses or tax credits which would otherwise be unused by either the parent or subsidiary can be used to offset taxable income of the more profitable unit, thereby reducing taxes to the consolidated entity. In this paper, the carve-out sample is further divided into the firms that own 80% or more ownership and those who own more than 50% but less than 80%.

As indicated by Harper and Madura (2002), the way tracking stock is distributed can affect agency relationship, that is, whether distributed as a stock dividend to current stockholders, through a public offering, or as a currency of acquisition. Tracking stock via an initial public offering is very similar to carve-out and may have the tendency to create free cash flow and transfer wealth between current and new shareholders. If the tracking stock shares are undervalued, then wealth is transferred to tracking stockholders when the parent managers distribute cash equally, or vice versa. Therefore, I will also divide the tracking stock sample into two subgroups, the group comprising of tracking stocks issued through initial public offering and the group created by means other than initial public offering.

V. EMPIRICAL RESULTS

V.1 Univariate Analysis

Table 6 indicates the comparison of SIC classification of tracking stock and carve-out samples. The manufacturing sector is most popular for restructuring for both carve-outs and tracking stocks. The telecommunication sector ranks second (30%) with the tracking stock group, while the energy sector ranks second with the carve-out sample.

Table 6:
Tracking Stocks and Minority Carve-Outs by Industry

Industry	Tracking Stock Sample	Carve-out Sample
Manufacturing:		
Food and Kindred Products	1	1
Lumber and Wood	0	1
Paper and Printing	2	0
Chemical and Applied Products	3	4
Petroleum Refining & Related	2	0
Primary Metal Industries	1	1
Industrial, Commercial Machinery Computer Equipment	1	3
Electrical Equipment	0	2
Transportation Equipment	0	3
Meas Instrument, Photo, and Watches	1	7
Miscellaneous Manufacturing industries	0	1
Transportation Services:	1	0
Tele Communication:	7	2
Energy Sector:	2	7
Wholesaling:		
Durable Goods	0	1
Non-durable Goods	1	0
General Merchandize Stores	0	2
Retailing:		
Home, Furniture & Equipment Stores	2	1

Table 6: (Continued)
Tracking Stocks and Minority Carve-Outs by Industry

Industry	Tracking Stock Sample	Carve-out Sample
Financial Services:		
Depository Institutions	0	3
Non-depository institutions	0	1
Brokers	1	2
Insurance Carriers	1	3
Holding, and other Investment offices		1
Entertainment & Services:		
	0	11
Total	26	57

Table 7 summarizes the description of the sample and reports the mean, median, mean difference and median difference between the tracking stock and carve-out groups. Since the sample size is small, the findings are interpreted based on the median comparison. The average asset size of the tracking stock and carve-out groups are approximately $21 million, $24 million respectively.

The managerial incentive measure, Theta, indicates the sensitively of the top five executives' wealth to share price scaled by the total compensation, including cash compensation, stock awards, long term investment pool, stock options, and other forms of compensation. The tracking stock sample has an average of 2.41, indicating that the compensation of the executives increased by 241% at T_{+1} compared to T_{-1}. In comparison, the carve-out sample shows about 32% increase. The mean difference is significant at the 5% level. Similarly, the median incentive score for the tracking stock sample is 50%, and that of the carve-out group is 0. The median difference is also significant at the 5% level. These results clearly suggest that the magnitude of the increases in stock-related compensation is higher for the tracking group than that of the carve-out group.

Table 7:

Descriptive Analysis of Variables of the Tracking Stock Sample and Carve-Out Sample

TA is the total assets in thousand dollars; THETA is the percentage change in stock related compensation after restructuring; DELTAC is the percentage change in compensation after restructuring; RES is the change in compensation resulted from the restructured units after restructuring; INS is the insider holding; INST is the institutional holding; BSIZE is the board size; REL is the measure of relatedness; INT is the interest coverage ratio before tax; INF is the information asymmetry measure; MB is the price-to-book ratio, the growth measure; and ROA is the return on assets. T-statistics of mean and median comparison are reported. ***, **, * represent the significant levels at 1 %, 5%, and 10% respectively.

	Tracking Stock Sample N=26		Carve-Out Sample N=57			
Variables	**Mean**	**Median**	**Mean**	**Median**	**t-Stat Mean**	**t-Stat Median**
TA	21,067	5,604	23,992	2,553	0.217	1.631
Theta	2.41	0.50	0.32	0	-1.981	-3.922***
DeltaC	2.37	0.50	0.67	0.31	-1.661*	-0.332
RES	0.14	0.04	0.01	0	-4.515***	-18.062***
INS	4.39	0.50	11.70	1.55	1.862*	1.013
INST	42.95	45.39	48.45	47.48	0.760	.605
BSIZE	11.30	11.50	9.86	10.00	-1.463	-1.854
RL	2.80	3.00	1.5	1.00	-3.728***	14.866***
INF	0.345	0.10	0.21	0.15	-1.308	0.488
INT	7.81	6.65	3.38	2.78	-1.816*	-3.807*
DEBT	23.63	20.75	31.07	24.59	1.327	0.782
MB	3.45	2.83	2.36	1.99	-0.992	-3.264
ROA	4.30	4.91	-3.61	2.02	1.067	4.964**

DELTAC is the percentage change in total compensation at T_{+1} compared to T_{-1}. The average increase in the total compensation for the tracking stock group is 136% while that of the carve-out sample is about 67%. The mean difference in DELTAC between the two groups is significant at the 10% level. However, the median percentage change in compensation after

the restructuring is 50.31% and 31.04% for the tracking stock group and the carve-out group respectively. The difference is not significant. Raltson-Purina and NTL in the tracking stock group have a significant increase in both THETA and DELTAC.

In particular, RES, the measure of extra compensation from the restructured subsidiary shows a significant difference between the tracking stock and the carve-out groups at the 1% level. Tracking stock sample exhibits a 14% increase in compensation, compared to a 1% increase for the carve-out sample.

Table 8 shows the extent of overlapping membership on the boards of parents and restructured units.

Table 8:

List of Firms with Extra Compensation from the Restructured Units

Parent Company Name	**Restructured Units**
Tracking Stock Sample:	
Genzyme	Genzyme Biosurgery
	Genzyme Molecular Oncology
US West	US West - Media
	US West – Communications
Pittston Company	Pittston - Burlington
	Pittston - Brinks
Sprint	Sprint - FON
Perkin Elmer	Celera Genomics
	PE Biosystems
Ziff Davis	ZDNet
Quantum	GMO
Walt Disney	Go.com
A T &T	AT & T Wireless
Carve-out Sample:	
WMS Industries	Midway Games Inc.
Commodore Environmental Services	Commodore Separation Technology
American Software Inc	Logility Inc.
Thermo Optek Corp	Thermo Vision
Titan Corp	SureBeam Corp

For 35% of tracking stocks parents' executives also sit on the board of tracking units and thus receive additional compensation from the units. On the other hand, only five out of fifty-seven firms have one or more directors on the board of the carved-out subsidiaries.

Board composition is also considered in the corporate governance framework. The tracking stock firms have a larger board of an average of 12 executives than the equity carve-out firms of 10. The board sizes of the carve-out group and tracking stock group, however, are not significantly different.

The insider holdings of the parents reflect the strength of stock-related compensation in motivating the executives to maximize shareholders' value. The average insider holding for the tracking stock sample is 4.39%, whereas that of the equity carve-out sample is 11.70%. The mean difference in insider holding between the tracking and the carve-out group is significant at the 10% level. Since firms that engaged in tracking stocks have lower insider holding, the interests of the insiders or officers might not be well aligned with those of the general shareholders. It is more likely that the executives of the tracking stock parents get into restructuring for their own benefits. The median institutional holdings for the tracking stock parent and the carve-out parent are 45% and 47% respectively. The difference is insignificant.

Information asymmetry measure is the absolute value of forecast error between the actual latest quarter earning per share and the forecasted earning per share, divided by the actual latest quarter earning per share. The higher the INF, the higher is the information asymmetry. The average forecast error for the tracking stock group is 0.35, whereas that of the carve-out sample is 0.21. However, the median of the two groups is closer, with 0.10 for the tracking stock group and 0.15 for the carve-out group respectively. The median difference between the tracking and the carve-out group is insignificant.

I consider the restructured unit and the parent firm to be related when the four-digit SIC code of the unit overlaps with one of the parent's four-digit SIC codes. The average value of REL for the tracking stock sample is 2.8 and the median is 3.0, compared to 1.5 and 1.0 of the carve-out sample. Differences in both the mean and median between the two groups are significant at the 10% level. This result is consistent with the empirical finding of Chemmanur and Paeglis (2000).

In terms of liquidity, tracking stock sample reports a significantly higher mean interest coverage ratio than that of the carve-out group. The differences in both mean and median are significant at the 10% level. This is consistent with the liquidity hypothesis that one of the major motives why parents carve out units is to raise capital. I also check to see if the lower interest coverage ratio of the carve-out sample is a result of higher leverage. Although the median debt ratio of the carve-out sample is higher (24.59%) than that of the tracking stock group (20.75%), this result is not statistically significant.

The carve-out group's higher need for capital does not appear to stem from higher growth potential, but from poor profitability. Indeed, parents of tracking stocks show higher (although not statistically significant) price to book ratio than the carve-out group. In terms of operating performance (return on assets), however, the carve-out group underperforms the tracking stock sample at a statistically significant level.[10] Taken together, these results imply that the major motive why parents create carve-out units is to raise capital.

V.2. Logistic Regression of Restructuring Choice

To investigate how managerial motives influence firms' restructuring decision, I run logistic regressions on managerial incentive measures, extra compensation from the restructured units, insider holdings, institutional holdings, information asymmetry measure, relatedness measure, profitability measure and growth measure.

[10] The big difference between mean and median is mainly due to the few firms like Sepracor Inc, who had a return on assets of -44.787%.

As shown in Table 9, I test four different models. Because THETA is the percentage change in stocks related compensation and DELTAC is the percentage change in total compensation at T_{+1} compared T_{-1}, they are not used in the same regression to avoid the problem of multicollinearity.

Table 9:
Logistic Regression on All Motives of Firms Choosing Tracking Stocks over Minority Equity Carve-outs

The table shows 4 logistic regression models on managerial motives. Where 0 is given to the firms engaged in minority equity carve-out, and 1 is given to the firms engaged in tracking stocks. THETA is the percentage change in stock related compensation after restructuring; DELTAC is the percentage change in compensation after restructuring; RES is the change in compensation resulted from the restructured units after restructuring; INS is the insider holding; INST is the institutional holding; BSIZE is the board size; REL is the measure of relatedness; INT is the interest coverage ratio before tax; INF is the information asymmetry measure; MB is the price-to-book ratio, the growth measure; and ROA is the return on assets. Figures in parentheses are t-statistics. **, * represent the significant levels at 5%, and 10% respectively. Sample size is 26 for the tracking group, and 57 for the carve-out group.

Variables	Model (1)	Model (2)	Model (3)	Model (4)
Intercept	-0.213	-0.228	-0.257	-0.319
THETA	0.219 (1.510)	0.192 (1.152)		
DELTAC			0.093 (0.598)	0.054 (0.314)
RES	0.274* (2.089)	0.284* (1.868)	0.270* (1.877)	0.294* (1.734)
REL	0.234* (1.702)	0.291* (1.889)	0.224 (1.559)	0.307* (1.946)
INT	0.330** (2.135)	0.387* (1.798)	0.359** (2.278)	0.445* (2.041)
INF		0.204 (1.274)		0.179 (1.094)
INST	-0.023 (-0.154)		-0.058 (-0.383)	-0.034 (-0.235)
MB	0.037 (0.259)	0.050 (0.261)	0.067 (0.467)	0.106 (0.552)
ROA	-0.094 (-0.638)	-0.058 (-0.247)	-0.104 (-0.683)	-0.123 (-0.511)
INS	-0.074 (-0.543)	-0.077 (-0.471)	-0.064 (-0.458)	-0.050 (-0.301)
BSIZE	0.113 (0.760)	0.046 (0.283)	0.157 (1.047)	0.096 (0.586)

I find RES, extra compensation from the restructured units, to be positively related to the restructuring choice. This relation is statistically significant. Holding other things the same, it is more likely that the firms that pay executives significantly higher extra compensation from the restructured unit after restructuring tend to choose tracking stock over carve-out as a restructuring vehicle. This might imply that executives expect to increase their extra compensation through tracking stocks. In addition, executives of a tracking stock's parent are in a "no loss" situation. If the unit performs well, they reap the benefit and if it does not, then the unit is reverted back to the parent and the parent's executives get to keep their original holdings. [11]

The extent of institutional and insider holdings might facilitate the self-serving behavior of tracking stock parents. The tracking stock parent has a lower insider holding (INS) than the parent of a carve-out unit, statistically significant at the 5% level. INST, the institutional holding, reflects the monitoring role of institutional investors. It is insignificantly negatively related to restructuring choice. A negative sign for this variable indicates that the parents with lower institutional ownership are more likely to choose tracking stocks over carve-out, thereby facilitating the self-interest motive of tracking stock parents.

THETA, the measure of changes in stock compensation after restructuring, is insignificant in determining the restructuring choice. A positive sign for THETA indicates that the parents that increase the weight of stocks and stock options in the compensation package of the executives prefer tracking stock to carve-out as a restructuring choice. The coefficient of DELTAC, the measure of changes in total compensation at T_{+1} compared to T_{-1}, is positive, but not significant.

[11] When Staples decided to convert its tracking stock Staples.com, which was announced but never went public, into parent's stocks, the critical shareholders perceive it as a sweetheart deal for stock-holding executives. Some shareholders even sued the company in Delaware chancery court. Finally, the directors of Staples voted on April 3, 2001 to forgo personal profits on a stock buyback, after facing lawsuits and shareholder criticism. (Business Week, April 2001).

INF, the information asymmetry measure, is not a significant factor determining the restructuring choice. However, the coefficient for REL is positive and significant at the 10% level. The result implies that the parents who are more related to the restructured subsidiaries are more likely to engage in tracking stocks than the counterparts. It is consistent with the parents' incentives to maintain positive synergy with the tracking units.

The coefficient for INT is positive and statistically significant. It is consistent with the proposition that the parents in poor liquidity position tend to choose carve-out, an initial public offering, to raise funds. The signs of proxy variables representing profitability, leverage, and growth are consistent with the results of univariate analyses. However, unlike in the case of univariate analyses, none of the coefficients is statistically significant.

In summary, liquidity motive appears to be the primary motive for firms to engage in equity carve-out, significant in all four models. On the other hand, the firms that pay significantly higher compensation from the restructured units after the restructuring tend to choose tracking stocks over carve-outs. The parents with lower insider holdings prefer tracking stocks to carve-outs as a restructuring choice for their self-serving intention. Reduction of information asymmetry does not appear to be a major determinant of restructuring choice.

V.3. Multiple Regressions of Long-Term Performance

V.3.1. Stock performance

Table 10 compares buy-and-hold stock returns of the parents who created tracking stocks with the same of parents who created carve-outs.

Table 10:

A Comparison of the Buy and Hold Stock Performance and Operating Performance of Firms that Engaged in Tracking Stocks or Minority Equity Carve- Outs.

The buy-and-hold return is defined as $[\prod_{T_1}^{T_2}(1+r_{it})]$, where T_1 is the date of the restructuring; T_2 is the ending date of the holding period, one year, two years and three years respectively; and r_{it} is the return for firm i on day t. T-statistics and significance level of median comparison are shown in parentheses. ** represents the significant level at 5%. Sample size is 26 for the tracking group, and 57 for the carve-out group.

	Tracking Stock Sample		**Minority Equity Carve-outs**			
	Mean	Median	Mean	Median	t-statistics Mean	t-statistics Median
Buy-and-Hold Return:						
One-year	0.005	0.021	-0.029	-0.045	0.243	0.324
Two-year	-0.113	0.083	0.055	0.091	-0.790	0.001
Three-year	-0.648	-0.160	0.287	-0.003	-2.069**	0.0620
Operating Performance:						
Change in Return on Assets	-0.569	-0.575	-0.750	-0.074	1.119	1.645

The return is computed for 1-year, 2-year, and 3-year after restructuring. The overall stock performance of tracking stock and carve-out samples is poor. The carve-out sample's buy-and-hold return improves from a negative in 1-year after the restructuring to 5% after two years, and 29% after three years. The performance of the tracking stock sample, however, deteriorates from a positive 0.46% one year after the restructuring to -11.27% after two years, and –64.84% after three years. The deteriorating performance, however, cannot solely be

attributed to the restructuring decisions, as many of the tracking stocks that originated in 1999 suffered a heavy set back. [12]

The average three-year buy-and-hold returns of the two groups are significantly different at the 5% level. Since the tracking stock and the carve-out samples are relatively small, the median difference may provide a better comparison of the two groups. The median difference of the tracking stock and the carve-out groups is not significant.

Table 11 compares the long-term stock performance and operating performance of the two subgroups of the carve-out sample-- one group owns over 80% of subsidiary unit, the other group owns between 50% and 80% of the unit. There is no significant difference in the long-term stock performance of return of the two subgroups. However, the operating performance of two groups differs significantly at the 1% level, with the ROA of the two groups being 11% and -37% respectively. The operating performance of the parents holding over 80% ownership of the carved-out subsidiaries improves significantly after restructuring than that of the group with an ownership between 50% and 80%.

[12] The stock performance of a large number of firms who created tracking stocks in 1999 deteriorated. In particular, eight firms in the telecommunication industry suffered from the relatively low stock return. The minimum three-year buy-and-hold stock return of the tracking stock sample is -109.03% belong to AT&T.

Table 11:

Stock and Operating Performance Comparison with Decomposition of Tracking Stock and Carve-out Samples

T-statistics and significance level of median comparison are shown in parentheses. *** represents the significant level at 1%. Sample size is 26 for the tracking group, and 57 for the carve-out group.

Carve-out sample:	**Ownership ≥ 80%**		**Ownership < 80%**			
	Mean	Median	Mean	Median	t-Stat Mean	t-Stat Median
Buy-and-Hold Return:						
One-year	-0.0265	-0.0446	-0.0153	-0.0327	-0.067	-0.077
Two-year	0.1156	-0.2832	-0.0058	0.0219	0.596	0.525
Three-year	0.3023	0.2438	0.2705	-0.0443	0.104	0.201
Change in Return on assets	-1.117	0.110	-0.633	-0.370	0.397	7.738***
Tracking stock with IPO	**Equity Carve-out**					
	Mean	Median	Mean	Median	t-Stat Mean	t-Stat Median
Buy-and-Hold Return						
One-year	-0.1935	-0.3470	-0.0289	-0.0446	-0.665	-0.669
Two-year	-0.1933	-0.0360	0.0552	0.0912	-0.677	-0.108
Three-year	-3.3684	0.0483	0.2874	-0.0032	-3.671***	0.071
Change in return on assets	-1.044	-0.135	-0.879	-0.074	-0.085	-0.219

V.3.2. Stock performance Related to Restructuring Motives

To determine the effect of a restructuring motive on the stock performance, I relate the three-year buy-and-hold return to the motives of the firms that engaged in the restructuring as shown in Table 12.

Table 12:

Multiple Regressions of Three-Year Long-Term Stock Performance on the Motives of Firms that Engaged in Tracking Stocks or Minority Equity Carve Outs

Multiple regressions are run on the motives of engaging into the restructuring decisions. CROA represents the changes in return on assets. THETA is the percentage change in stock related compensation after restructuring; DELTAC is the percentage change in compensation after restructuring; RES is the change in compensation resulted from the restructured units after restructuring; INST is the institutional holding; REL is the measure of relatedness; INT is the interest coverage ratio before tax; INF is the information asymmetry measure; MB is the price-to-book ratio, the growth measure; and ROA is the return on assets. Figure in the parentheses are t-statistics. ***, **, * represent the significant levels at 1 %, 5%, and 10% respectively. Sample size is 26 for the tracking group, and 57 for the carve-out group.

Variables	**Tracking Stocks**		**Minority Equity Carve-outs Sample**	
Intercept	1.784	0.070	0.878	0.583
THETA	1.981** (5.793)		-0.049 (-0.347)	
DELTAC		0.579 (4.255)		-0.037 (-0.221)
RES	-0.667* (-3.389)	-1.155* (-6.769)	0.258* (1.878)	0.259 (1.624)
REL	-0.680 (-2.355)	0.569 (2.963)	-0.451*** (-3.176)	-0.486*** (-3.363)
INF	0.445* (2.947)		0.392** (2.662)	
INT	1.110 (1.734)	-0.590 (-1.289)	-0.093 (-0.423)	-0.066 (-0.428)
INST		0.262 (2.238)		0.260 (1.691)
MB	-3.885* (-4.323)	-0.239 (-0.522)	-0.342** (-2.249)	-0.414*** (-2.873)
ROA	1.578** (5.081)	0.064 (0.337)	0.207 (0.884)	0.084 (0.496)

For the tracking stock sample, RES, the extra compensation from the restructured unit, is significantly negatively related to the three-year average buy-and-hold return. In other words, the greater the additional compensation from the tracking divisions, the poorer the performance. It is consistent with the proposition that the parent's managers create tracking stock unit as a means to receive additional compensation at the expense of shareholders.

Consequently, the expected benefit from incentive alignment does not materialize. Contrarily, carve-out parents whose executives are on the board of directors of both the parent and the restructured unit earn higher buy-and-hold returns than the group with no overlapping board membership. The difference is significant at the 10% level.

THETA, the sensitivity of executives' wealth to stock price changes after the restructuring decision, is positively related to the three-year buy-and-hold stock performance of the tracking stock parents and significant at the 5% level. Although not statistically significant, the relationship between DELTAC and performance is positive. In contrast, for the carve-out group, the relationship between both THETA and DELTAC on the one hand and long-term stock performance on the other is negative. Thus, increased compensation does not seem to result in improved performance of the carve-out parents.

REL, the relatedness of the restructured unit to the parent, does not have a significant relation with the performance of the tracking stock parents. However, it is negatively related to the three-year buy-and-hold stock performance of the carve-out group and it is significant at the 1% level. In other words, the lower the relation of the unit with the parent, the better the performance of the parent firm. It suggests that the investors recognize the benefits of being focused by the parent firm.

INF, the information asymmetry measure, is positively related to the long-term performance of both the tracking stock and the carve-out groups. The parent firms with higher information asymmetry before restructuring tend to have better long-term stock performance. This implies that the investors reward the reduction in information asymmetry via restructuring.

Liquidity is not significantly to the performance of either group. Indeed, the relation, although statistically insignificant, is negative between the interest coverage ratio and the stock performance for the carve-out group. This implies that the poorer the liquidity of the

parent firm, the better the long-term performance for the carve-out parent. MB, the measure of firm's growth potential, is negatively related to the long-term stock performance for the carve-out group and is significant at the 5% level. That is, the firms with high growth potentials appear to have low long-term stock performance three years after the restructuring. This can be understood that the firms with high growth potential needs financing support, restructuring though carve out provides the firms the option of getting funds. However, the funds provided by the initial public offering seem not enough to realize the growth potential in the long run. ROA, the measure of profitability, is positively related to stock performance for the tracking stock group and is significant at the 5% level. (in one model). A tracking stock parent with high profitability before restructuring tends to have higher long-term stock performance.

In summary, for the parents of the tracking stock sample, the higher the executive compensation from the tracking units, the lower buy-and-hold return for parents. However, the relation is not statistically significant. The relatedness and growth potential are significantly negatively related to the long-term stock performance of the carve-out sample, indicating that the parents that carve out the less related units performed better in the long run.

V.3.3. Operating Performance

Table 13 compares the operating performance for the tracking stock and the carve-out groups. Both groups experience a decrease in return on assets three years after the restructuring as shown in Table 10. The mean decrease in return on assets is 56.9% for tracking stock parents and 75% for the carve-out parents. The median decreases in return on assets for the two groups are large as well 57.5% for tracking stock parents and 7.4% for the carve-out parents. However, neither is statistically significant.

Table 13:

A Comparison of the Changes in Operating Performance of Firms that Engaged in Tracking Stocks or Minority Equity Carve Outs

Multiple regressions are run on the motives of engaging into the restructuring decisions. CROA represents the changes in return on assets. THETA is the percentage change in stock related compensation after restructuring; DELTAC is the percentage change in compensation after restructuring; RES is the change in compensation resulted from the restructured units after restructuring; INST is the institutional holding; REL is the measure of relatedness; INT is the interest coverage ratio before tax; INF is the information asymmetry measure; MB is the price-to-book ratio, the growth measure; and ROA is the return on assets. Figures in parentheses are t-statistics. ** represents the significant level at 5%. Sample size is 26 for the tracking group, and 57 for the carve-out group.

Variables	**Tracking Stocks**		**Minority Equity Carve-outs**	
Intercept	-0.671	-1.079	0.515	0.367
THETA		-2.053 (-1.798)		-0.020 (-0.093)
DELTAC	-1.534 (-1.517)		-0.137 (-0.552)	
RES	-0.140 (-0.149)	-0.062 (-0.069)	-0.009 (-0.039)	-0.061 (-0.303)
REL	0.456 (0.370)	0.752 (0.628)	-0.465** (-2.196)	-0.471** (-2.214)
INT	-0.593 (-0.265)	-1.053 (-0.492)	0.017 (0.058)	0.045 (0.153)
INF	-0.261 (-0.581)	-0.266 (-0.654)	0.160 (0.751)	0.157 (0.729)
MB	2.699 (0.824)	3.923 (1.151)	-0.069 (-0.239)	-0.027 (-0.090)
ROA	-1.218 (-1.505)	-1.403 (-1.824)	-0.068 (-0.181)	-0.103 (0.270)

V.3.4. Operating Performance Related to Restructuring Motives

To investigate whether the change in operating performance is related to restructuring motives, I regress the change in return on assets on the various motives. Using THETA and DELTAC one at a time in the equations, I find none of the motives has significant relationship with the performance of the tracking stock group. However, relatedness is

negatively related to the operating performance of the carve-out group and this relation is significant at the 10% level. This suggests that the less closely related the unit is to the parent, the better the operating performance for the parent. To divest a subsidiary through equity carve-out with which the parent has low positive synergy can help the parent remain focused and at the same time bring funds for investment.

RES, the extra compensation from the restructured unit, is negatively related to the change in return on assets for both the tracking stocks and the carve-out groups. However, in neither case, the relation is statistically significant. This suggests that the higher the additional compensation the parent receive from the restructured unit, the poorer the operating performance for the parent.

THETA and DELTAC, the compensation incentive measures, are negatively related to the change in return on assets for both groups. Though the relationship is not significant, the result implies that increased compensation does not entail improved operating performance. Information asymmetry measure is negatively related to operating performance of the tracking group, but the relation is not significant. In contrast, the relation is positive, although insignificant, for the carve-out group.

The relation between interest coverage ratio and operating performance is opposite for the two groups. For the carve-out group, the relation is positive, while the same for the tracking stock parents. The negative relationship exists between pre-restructuring and post-restructuring ROAs for parents of both groups. Although the relation is insignificant, it suggests that parent firms with lower pre-restructuring ROA show more improvement in the post-restructuring ROA. The relation between market to book ratio and operating performance is opposite for the two groups—negative for carve-out parents and positive for the tracking stock parents. Although not statistically significant, the opposite results suggest

that carve-out parents with higher growth potential did not improve, while the opposite holds true for the tracking stock group.

VI. CONCLUSIONS

Empirical evidence supports the proposition that the factor that motivates the firm to choose tracking stock over minority equity carve-out is that tracking stock structure provides the executives a means of earning additional compensation from stocks and stock options of the tracking units. The control mechanism of the tracking stock structure with the same board of directors serving on the parent and the subsidiary creates conflicts of interests and causes the long-term buy-and-hold stock performance to be significantly lower than that of the carve-out group. Use of tracking stocks to align managers' interests and reduce information asymmetry does not appear to be related to post-restructuring operating and stock performance. The primary motivation of engaging in equity carve-outs is to raise capital. The parent receives better stock returns when the restructured unit is less related to parent's business.

Regarding the operating performance, parents of both the carve-out and tracking stock group experience a decrease in return on assets three years after the restructuring. However, when a parent carves out less related unit, it outperforms the parent that carves out a more related unit.

In conclusion, the fact that the executives weigh self-interests over the shareholders' interests in the tracking stock structure may explain why executives prefer tracking stocks to equity carve outs. This may explain why in spite of increased incentive alignment the parents of stock exhibit poor long-term stock performance. The financing motives and desire to remain focused motivate the parent to engage in equity carve out. It is value enhancing if the parent firms carve out less related subsidiaries.

CHAPTER 2

IS OVERREACTION AN EXPLANATION FOR THE VALUE EFFECT? A STUDY USING IMPLIED VOLATILITY FROM OPTION PRICES

I. INTRODUCTION

Many empirical studies indicate that value stocks outperform growth stocks in the long-term, either measured by total return or risk-adjusted return (e.g., Fama and French. (1992, 1996); Lakonishok, Shleifer, and Vishny, (1994); Bauman and Miller, (1997)). The explanations for the value stock effect however are not clear. Efficient market arguments (e.g., Fama and French, (1992)) suggest that firms with a low price-to-book ratio may be riskier and as a result command a higher risk premium. On the other hand, the rationale behind value investing is that investors overreact to lack of growth opportunities for value stocks and/or they overreact to growth prospects for growth stocks (e.g., Graham (1962)); consequently, value stocks may be under-priced while growth stocks are over-priced. The issue has important implications for individual investors as well as institutional ones. For instance, Morningstar classifies mutual funds' investment styles into value or growth oriented. By using the methodology first proposed by Stein (1989), this study contributes to the existing literature on the overreaction explanation for the price-to-book effect.

Stein (1989) analyzes the term structure of options' implied volatility to infer the degree of investor overreaction. Intuitively, if stock prices have a tendency to return to their long-term mean, long-term investors revise their expectations for future volatility to a smaller extent than their short-term counterparts do. The expectation for future volatility can be inferred from option prices, commonly referred to as implied volatility. Therefore, implied volatility is the current consensus of anticipated future volatility by market participants, and it

reflects the market sentiment for the underlying security. Stein's (1989) empirical results using S&P 100 index options show that implied volatility for long-term options moves almost in lockstep with short-term options, thereby suggesting overreactions. However, Diz and Finucane (1993) and Heynen, Kemna, and Vorst (1994) show that the degree of overreaction is sensitive to statistical specifications and assumptions about the underlying stock return generating process.

This paper applies Stein's (1989) mean reversion model and Heynen, Kemna, and Vorst's (1994) GARCH and EGARCH methods to investigate whether the degree of overreaction differs between value and growth stocks. To the author's knowledge, there is no similar research on this issue. One study that is somewhat related is the one by La Porta, Lakonishok, Shleifer, and Vishny (1997). They examine stock price reactions to earning announcements and conclude that a significant portion (roughly one third of the first two years) of the difference in return between value stock and growth stock is explained by more systematically positive earning surprises for value stocks. Bauman and Miller (1997) document similar findings. However, none of these studies directly infers investors' expectations.

A finding of overreaction for either value stocks or growth stocks could lend support to overreaction as an explanation for the value stock effect. Absence of overreaction could be interpreted as evidence that investors in various types of stocks are not fundamentally different, which is plausible considering that institutional investors hold a large portion of shares and are fairly diversified. The focus here is whether the degree of overreaction differs between value and growth stocks. The problems as indicated by Diz and Finucane (1993) and Heynen, Kemna, and Vorst (1994) would have little effect on the results, unless measurement problems are more severe for a particular group of stocks. Moreover, this study estimates implied volatility for individual stocks formed by two different criteria, as opposed to

previous studies that use index options, allowing for a richer set of testing. The empirical evidence suggests that the growth investors largely overreact to a larger degree than the value investors, offering support to overreaction as an explanation to the value effect.

The rest of the paper is organized as follows. Section 2 covers the review of the relevant literature. Section 3 illustrates the theoretical framework for each model and states the hypotheses. Section 4 describes the data and the methodology. Section 5 presents the empirical results. The last section concludes.

II. RELEVANT LITERATURE

II. 1 Value Stock Effect

Fama and French, (1992, 1996), Lakonishok, Shleifer, and Vishny, (1994) and Bauman and Miller (1997) document that value stocks produce higher returns than growth stocks in the U.S. stock market. Recently Beneda (2002) examines the performance of growth versus value stock portfolios created during the period 1983-1987. Consistent with prior studies, the five-year returns of value stocks exceed those of growth stocks. However, the long-term buy-and-hold returns (up to 18 years) of growth stocks are higher than those of value stocks for portfolios created during the years included in the study. Nevertheless, it is likely that, after a five-year run-up, some value stocks would be classified as growth stocks. Furthermore, her time period mainly covers 1990s, a period when growth stocks perform exceptionally well. The stock returns are not adjusted for market returns as well.

In addition to the considerable empirical research for the U.S. stock market, some studies compare the performances of value and growth stocks in the stock markets in other countries. Value and growth stocks may perform differently in non-U.S. markets because of the variations in investors' behavior and/or market conditions. For example, Bauman (1996) observes that the availability, quality, and timeliness of research information vary substantially from one country to another. Capaul, Rowley, and Sharpe (1993), using price-to-book ratios, find that value stocks outperformed growth stocks in France, Germany, Japan, and the United Kingdom in the 1981-1992 period. Fama and French (1998) conclude that value stocks tend to have higher returns than growth stocks in 12 of 13 major markets during 1975-1995 period and the difference between average returns on global portfolios of high and low book-to-market stocks is 7.6% per year.

Researchers have offered two primary explanations for the performance difference. Fama and French (1992, 1996) suggest that price-to-book and firm size may proxy for risk. Thus the fact that value stocks might be considerably riskier than growth stocks account for their superior return. However, Fama and French (1992) find evidence to the contrary - stocks with low price-to-book value ratios are characterized by lower betas. If beta represents the systematic risk of a stock, value stocks with low price-to-book ratios are supposed to have higher beta than growth stocks.

Lakonishok, Shleifer, and Vishny (1994) argue that investors erroneously extrapolate past earnings growth too far into the future and therefore cause stock prices to deviate from their 'fundamental' value. Future earnings of firms that recently performed badly - more likely to be relatively small and have a high book-to-market ratio - are underestimated, whereas growth stocks or large stocks are overestimated. Based on the stock price reactions around earnings announcement for value and growth stocks over a five-year period after portfolio formation, La Porta, Lakonishok, Shleifer, and Vishny (1997) find that a significant portion of return difference between value and growth stocks is attributable to earnings surprises that are systematically more positive for value stock, which is inconsistent with a risk-based explanation for the return differential. Instead, they argue that value stocks have been under-priced relative to their risk and return characteristics. Bauman and Miller (1997) enhance the argument by showing that investment research analysts systematically overestimate the future earning per share of growth stocks relative to value stocks; as a result, growth stocks experience lower returns subsequently when realized earning per share growth rates are disappointingly lower than those that were expected.[13]

The greater information asymmetry inherited in growth stocks can make growth stocks sensitive to changes in investor sentiment. Copeland and Copeland (1999) suggest an

[13] Bauman and Miller (1997) observe that the EPS growth rate has a mean-reversion tendency, over time, in which the high growth rates associated with growth stocks subsequently tend to decline whereas the low growth rates associated with value stocks tend to increase.

investing strategy that involves switching between value stocks and growth stocks. When the estimate of expected future volatility goes up, the rising uncertainty about the future might lead to falling confidence in growth stocks and investors shift into value stocks. When the estimated future volatility goes down, investors are likely to shift into growth stocks on the assumption that decreases in expected volatility signal rising confidence in the future, a condition that favors growth stocks. They find evidence supporting the effectiveness of the strategy.

II. 2 Term Structure of Implied Volatility

Stein (1989) examines the term structure of implied volatilities, using two daily time series on implied volatilities for S&P 100 index options over the period from December 1983 to September 1987. Based on the assumption that the volatility follows a mean reverting process with a constant long-run mean and a constant coefficient of mean reversion, changes in long-term implied volatility should be less than those of short-term. Instead, he finds that implied volatility of long-term and short-term options move almost in perfect lockstep. The correlation between long-term and short-term implied volatility is close to one. Therefore, he concludes that this presents evidence for overreaction.

Nevertheless, Diz and Finucane (1993) and Heynen, Kemna, and Vorst (1994) question the evidence of overreaction. Diz and Finucane (1993) indicate that the relation between long and short options cannot be constant. They use changes in implied volatility as opposed to the level of implied volatility and find no evidence for overreactions for S&P 100 stock index. Heynen, Kemna, and Vorst (1994) utilize one year's data on the European Option Exchange and the Amsterdam Stock Exchange. They test restrictions on implied volatilities under mean reverting model, GARCH model and EGARCH model and find that their conclusion about overreaction depends on the model specifying the process of price

volatility. EGARCH model gives the best description of asset prices and the term structure of options' implied volatilities and indicates no overreaction. On the other hand, assuming mean reverting and GARCH models, the evidence is in favor of overreaction. Nevertheless, they find that none of the models is misspecified, as a result they cannot reach defined conclusions on whether investors overreact to information. Poteshman (2001) examines whether the long-horizon overreaction documented by Stein (1989) in the OEX market is present in the S&P 500 (SPX) index options market in a later period. Employing a standard variance model, he separates daily changes in instantaneous variance into expected and unexpected parts and assumes investors respond to the unexpected part when they set option prices. The evidence indicates that SPX options market investors underreact to daily information and overreact to extended periods of mostly similar daily information and exhibit increasing misreaction to daily information as a function of the quantity of previous similar information.

In summary, the empirical results on the term structure of implied volatility of options are mixed and the underlying reasons for the different performance between growth stock and value stocks remain an open question.

III. THEORETICAL FRAMEWORK AND HYPOTHESES

Stein (1989) assumes that instantaneous volatility σ_t evolves according to continuous-time mean reverting AR1 process as follows.

(Equation 1)

$$d\sigma_t = -\alpha(\sigma_t - \overline{\sigma})dt + \beta\sigma_t dz$$

At time t, the expectation of volatility as of time t+j is given by

(Equation 2)

$$E_t(\sigma_{t+j}) = \overline{\sigma} + \rho^j(\sigma_t - \overline{\sigma})$$

Where ρ is the autocorrelation coefficient of implied volatility of short-term stock options at a one-day lag. $\rho = e^{-\alpha} < 1$. That is, volatility is expected to decay geometrically back towards its long-run mean level of $\overline{\sigma}$.

Denoted by $V_t(T)$, the implied volatility at time t on an option with T remaining until expiration should equal to the averaged expected instantaneous volatility over the time span [t, t+T]. Using Equation 1, this implies

(Equation 3)

$$V_t(t) = \frac{1}{T}\int_{j=o}^{T}[\overline{\sigma} + \rho^j(\sigma_t - \overline{\sigma})]dj = \overline{\sigma} + \frac{\rho^T - 1}{T\ln\rho}[\sigma_t - \overline{\sigma}]$$

Suppose there are two options of different terms to maturity: a short-term option with time to expiration T and implied volatility $V_t^S(T)$, and a long-term option with time to

expiration K, which is n days longer than T (K=T+n) and implied volatility $V_t^L(K)$, the following relationship is expected to hold.

(Equation 4)

$$(V_t^L - \overline{\sigma}^2) = \theta(\rho, T) * (V_t^S - \overline{\sigma}^2)$$

Where

$$\theta(\rho, T) = \frac{T(\rho^{T+n} - 1)}{(T+n)(\rho^T - 1)}$$

θ represents the theoretical elasticity of the implied volatility of long-term stock options with respect to that of the short-term option. Given a movement in the implied volatility of short-term option V_t^S, there should be a smaller movement in the implied volatility of long-term option V_t^L. The exact proportion depends on the mean reversion parameter ρ, as well as on the times to expiration of the two options.

However, empirical evidence in recent studies indicates that the assumption of constant conditional means and variances for stock returns is unrealistic (Poterba and Summers, 1986). Bollerslev's (1986) Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model and Nelson's (1991) Exponential GARCH (EGARCH) model are widely used to describe the stock price dynamics. Further research indicates GARCH model is very useful in modeling the relationship between a stock's expected return and risk. In the case of a GARCH (1,2) specification, stock return and stock return volatility are modeled as follows,

Equation (5)

$$R_t = r + \lambda\sigma_t - \frac{1}{2}\sigma_t^2 + \varepsilon_t + \beta\varepsilon_{t-1}$$

Equation (6)

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 + \alpha_3 \varepsilon_{t-2}^2$$

Where R_t is the daily stock return, σ_t is the stock return volatility, r is the risk-free rate, λ is the unit risk premium, $\alpha_0, \alpha_1,$ and α_2 are independent parameters, and ε_t is Gaussian white noise. From Equation (6), one can observe that the conditional stock volatility is a function of the volatility of one period earlier and the shock during that period. Thus, the model allows for clustering of periods with high volatility and periods with low volatility. The relationship between expected volatilities differing in time to maturity derived by Heynen, Kemna, and Vorst (1994) is as follows,

Equation (7)

$$(V_t^L - \overline{\sigma}^2) = \theta(\gamma, T) * (V_t^S - \overline{\sigma}^2)$$

Where

$$\theta(\gamma, T) = \frac{T(\gamma^{T+n} - 1)}{(T+n)(\gamma^T - 1)}$$

$$\overline{\sigma}^2 = \frac{\alpha_0}{1 - \alpha_1 - \alpha_2}, \text{ and } \gamma = \alpha_1 + \alpha_2$$

$\overline{\sigma}^2$ is the unconditional volatility. The Theoretical theta θ therefore depends on the independent parameters $\alpha_0, \alpha_1,$ and α_2.

Another description of stock return given by Nelson (1991) is the EGARCH (1,1) specification. Stock return and stock return volatility are modeled as follows,

Equation (8)

$$R_t = r + \lambda \sigma_t - \frac{1}{2}\sigma_t^2 + \sigma_t \varepsilon_t$$

$$Ln\sigma^2 = \alpha_0 + \alpha_1 Ln\sigma_{t-1}^2 + \alpha_2 \varepsilon_{t-1} + \alpha_3 (|\varepsilon_{t-1}| - \sqrt{\frac{2}{\pi}})$$

Where R_t is the daily stock return, σ_t is the stock return volatility, $\alpha_0, \alpha_1, \alpha_2,$ and α_3 are independent parameters, and ε_t is Gaussian white noise.

Heynen, Kemna, and Vorst (1994) test the term structure of implied volatilities as follows,

Equation (9)

$$(LnV_t^L - Ln\overline{\sigma}^2) = \theta(\gamma, T) * (LnV_t^S - Ln\overline{\sigma}^2)$$

Where

Equation (10)

$$\theta(\gamma, T) = \frac{T(\gamma^{T+n} - 1)}{(T+n)(\gamma^T - 1)}$$

and $\gamma = \alpha_1$

$\overline{\sigma}^2$, the unconditional volatility, is a function of parameters of the model as below.

Equation (11)

$$\overline{\sigma}^2 = \exp[\frac{\alpha_0 - \alpha_3\sqrt{\frac{2}{\pi}}}{1-\alpha_1} + \frac{1}{2}\frac{(\alpha_2^2 + \alpha_3^2)}{1-\alpha_1^2}] * \prod_{j=0}^{\infty}[F_j(\alpha_1, \alpha_2, \alpha_3) + F_j(\alpha_1, -\alpha_2, \alpha_3)]$$

Where

Equation (12)

$$F_j(\alpha_1, \alpha_2, \alpha_3) = V[\alpha_1^j(\alpha_2 + \alpha_3)]\exp[\alpha_1^{2j}\alpha_2\alpha_3]$$

Equation (13)

$$F_j(\alpha_1, -\alpha_2, \alpha_3) = V[\alpha_1^j(-\alpha_2 + \alpha_3)]\exp[-\alpha_1^{2j}\alpha_2\alpha_3]$$

Equation (14)

$$V(b) = (\frac{1}{\sqrt{2\pi}}) \int_{-\infty}^{b} e^{-\frac{Z^2}{2}} dz$$

In summary, the main difference among Equation (4), (7) and (9) on the term structure of implied volatility is the level of unconditional volatility and the different parameters for the three specifications. Therefore, the theoretical value of theta, the elasticity of long-term implied volatility in response to the change in short-term implied volatility, varies according to the different parameter estimates. The theoretical theta can be generalized as a function of parameter p, and time to maturity T as follows.

Equation (15)

$$\theta(p,T) = \frac{T(p^{T+n} - 1)}{(T+n)(p^{T} - 1)}$$

Where

p = ρ, the autocorrelation coefficient assuming that the implied volatility is mean reverting.

p = γ, a function of parameter estimates from the GARCH and the EGARCH specifications for the stock return.

In this paper, the mean reversion, GARCH and EGARCH models are applied to test the term structure of implied volatility. For each model specification, I test the hypothesis that the long-term implied volatility is formed rationally based on the theoretical theta, the elasticity of long-term options in respect to short-term options. In particular, I test whether the average variation of implied volatility of the growth stock options over time is higher than that of the value stock options, demonstrating a greater degree of overreaction.

IV. DATA AND METHODOLOGY

Daily option data from July 2000 to December 2002 provided by Prophet Financial System, a relatively comprehensive database after Berkley Options database became unavailable, are used for the study. The dataset include open price, close price, high and low prices, trading volume and open interests for call and put contracts of stock options. Daily stock price, stock return, interest rates, and accounting data are extracted from CRSP and Compustat.

I restrict the sample to stocks within S&P 100 index to ensure relatively active trading of each stock and a continuous time-series of implied volatility for analysis. A continuous time series of implied volatility is critical to calculate ρ, the autocorrelation coefficient of the implied volatility of short-term option series, an input for the latter computation of theoretical theta. The theoretical theta will not be reliable if ρ is found from a discontinuous time series. In addition, without active trading in a stock option, the implied volatility would be constant, which is against the objective of the study, to compare the degree of changes in implied volatility between value and growth stocks. S&P 100 stocks meet the criterion of the study since they are widely traded and comprise of stocks with various growth aspects. In the case of any possible non-trading days for certain sample stocks, I use linear interpolation method to replace the missing values to ensure a continuous time series before building the equally-weighted and the value-weighted implied volatility series of value and growth portfolios.

The finance literature generally classifies value stocks and growth stocks according to the earning yield and book-to-market value ratios. Typically, value stocks are those whose market price is relatively low in relation to earnings per share (Basu 1977), cash flow per share (Lakonishok, Shleifer, and Vishny 1994), book value per share (Fama and French 1992), and dividends per share (Blume 1980 and Rozeff 1984). In comparison, growth stocks

have been defined as having relatively high prices in relation to those same fundamental factors, as well as high past rates of growth in earning per share.

However, there was no one variable that appeared to be better than the others in identifying value stocks that outperformed the market. In Lakonishok, Schleifer, and Vishny's (1994) study, price-to-cash flow appears to be an indicator of value that leads to more significant mean difference than price-to-earning or price-to-book value. In Bauman, Conover and Miller's (1998) study, price-to-book value rather than price-to-earning, price-to-cash flow, or dividend yield is the indicator of value that reports a more significant mean difference. Fama and French (1998) classify value and growth portfolios formed on four measures, book-to-market (B/M), earning to price (E/P), cash flow to price (C/P) and dividend to price ratios (D/P) respectively. The value portfolio includes firms whose B/M, E/P, C/P or D/P are among the highest 30% for a country, and growth firms include firms in the bottom 30%. In this paper, I rank the S&P 100 stocks by both price-to-book ratio and price-to-earning ratio. The top 30% is classified as growth portfolio, and the bottom 30% falls into value portfolio. The remaining 40% are eliminated.

The initial dataset of S&P 100 contains about ten million records over the sample period from 2000 to 2002. Eliminating 40% of the initial set, that is neither growth nor value stock, we end up with six million observations. Since there might be multiple option contracts with different strike prices matured on the same day and not all of them contain active trading records, I screen the dataset and retain one near-the-money option contract with a relatively large number of observations for each sample stock each month and build continuous short-term and long-term series. The screening criterion is to retain the contracts with the least number of observations with the same open price, close price, high price, and low price. This enables retaining contracts with active trading for the calculation of implied volatility.

For estimating implied volatility, I use the Binomial Option Pricing model by Cox, Ross and Rubinstein (1979). It explicitly accounts for the discrete dividend on the stock option and for the possibility of early exercise to calculate the implied volatility. After deriving the implied volatility of individual stock, I create two time series for both the value and the growth portfolios. The short-term series consists of observations with one day up to one month to expiration. The long-term series consists of observations with thirty-one days up to two months to expiration.

Moreover, for each time series implied volatility is calculated by averaging the implied volatility of call and put contracts near the money. Then I build the equally-weighted and the value-weighted implied volatility of value or growth portfolios by multiplying the implied volatility of each stock in value or growth portfolios by its weight on each day. Eventually I have 626 daily observations for each series from July 2000 to December 2002 for analysis.

To obtain the empirical theta from the implied volatility series, I run OLS regressions of V_t^L against V_t^S for each portfolio. The coefficient of V_t^S indicates the actual elasticity of long-term options in respect to short-term options. If the empirical theta is greater than the theoretical theta, then the long-term contracts overreact to the short-term contracts. If the difference between empirical theta and theoretical theta is greater for growth portfolio than for value portfolio, then there is a greater degree of overreaction in growth portfolio than in value portfolio, or vice versa.

Since the theoretical theta is a function of parameters under different specifications of stock returns, I estimate the autocorrelation coefficients and GARCH and EGARCH parameters using portfolio return for both the equally-weighted and the value-weighted portfolios. Then empirical theta is compared with theoretical theta and T tests are conducted to check for the significant difference between the two. Finally, I draw conclusion based on

the comparison of T-values of the growth and the value portfolios as to whether there is support for the overreaction as an explanation for the value effect.

V. EMPIRICAL RESULTS

V. 1 Descriptive Analysis

Table 14 and Table 15 list the firms in the value and growth portfolios formed by price-to-book and price-to-earning ratios. Each portfolio consists of 30 firms.

Table 14:

List of Value and Growth Portfolios Classified by Price-to-Book Ratio for the Sample Period from 2000 to 2002.

Company Name	Ticker	Company Name	Ticker
Growth Portfolio		**Value Portfolio**	
American Int'l Group Inc.	AIG	Alcoa Inc.	AA
Amgen Inc	AMGN	American Electric Power	AEP
American Express	AXP	AVON Products	AVP
Boeing Co.	BA	Bank of America Corp	BAC
Baxter International Inc.	BAX	Brunswick Corp	BC
Bristol Myers Squibb	BMY	Boise Cascade Corp	BCC
Colgate-Palmolive Co.	CL	Burlington Northern Santa Fe	BNI
Campbell Soup Co.	CPB	Delta Airlines	DAL
CISCO Systems Inc.	CSCO	Disney	DIS
General Electric Co.	GE	Entergy Corp	ETR
Home Depot Inc.	HD	Fedex Corp	FDX
Int'l Business Machines Corp	IBM	General Motors Corp	GM
Intel Corp	INTC	International Paper Co.	IP
Johnson & Johnson	JNJ	J P Morgan Chase & Co.	JPM
Coca-Cola Co.	KO	Lucent Technologies	LU
McDonalds Corp	MCD	Merrill Lynch & Co.	MER
3M Co.	MMM	Norfolk Southern Co.	NSC
Altria Group Inc.	MO	National Semiconductor Co.	NSM
Merck & Co.	MRK	Bank One	ONE
Microsoft Corp	MSFT	Occidential Petroleum Co.	OXY
Nortel Networks Corp	NT	Raytheon Co.	RTN
Oracle Corp	ORCL	Sears Roebuck & Co.	S
PepsiCo Inc.	PEP	Southern Co.	SO
Procter & Gamble Co.	PG	AT&T Corp	T
Radioshack Corp	RSH	Tektronix Inc.	TEK
Sara Lee Corp	SLE	Toys R US	TOY
Texas Instruments Inc.	TXN	Unisys Corp	UIS
United Technologies Corp	UTX	Williams Co.	WMB
Wal-mart Stores	WMT	Weyerhaeuser Co.	WY
Exxon Mobil Corp	XOM	Xerox Corp	XRX

Table 15:

List of Value and Growth Portfolios Classified by Price-to-Earning Ratio for the Sample Period from 2000 to 2002.

Company Name	Ticker	Company Name	Ticker
Growth Portfolio		**Value Portfolio**	
Bank of America Corp	BAC	American International Group	AIG
Brunswick Corp	BC	Amgen Inc.	AMGN
Boise Cascade Corp	BCC	Avon Products	AVP
Black & Decker Corp	BDK	Baxter International Inc.	BAX
Burlington Northern Santa Fe Corp	BNI	Baker-Hughes Inc.	BHI
Eastman Kodak Co.	EK	Bristol Myers Squibb	BMY
Entergy Corp	ETR	Ceridian Corp	CEN
Ford Motor Co.	F	Colgate-Palmolive Co.	CL
General Motors Corp	GM	CISCO Systems Inc.	CSCO
HCA Inc.	HCA	Delta Airlines Inc.	DAL
Harrahs Entertainment Inc	HET	DU PONT (E I) De Nemours	DD
Int'l Flavors & Fragrances	IFF	Disney (Walt) Co.	DIS
J P Morgan Chase & Co.	JPM	General Electric Co.	GE
Kmart Holding Corp	KMRT	Halliburton Co.	HAL
Limited Brands Inc	LTD	HCA Inc.	HCA
Lucent Technologies Inc.	LU	Home Depot Inc	HD
May Department Stores Co.	MAY	Johnson & Johnson	JNJ
Massey Energy Co.	MEE	Coca-Cola Co.	KO
Merrill Lynch & Co.	MER	Lucent technologies Inc.	LU
Microsoft Corp	MSFT	Merck & Co.	MRK
Altria Group Inc.	MO	Bank One Corp	ONE
National Semiconductor Corp	NSM	PepsiCo Inc.	PEP
Nortel Networks Corp	NT	Procter & Gamble Co.	PG
Occidental Petroleum Corp	OXY	Raytheon Co.	RTN
Sears Roebuck & Co.	S	Schlumberger Ltd.	SLB
AT&T Corp	T	Tektronix Inc.	TEK
Toys R US Inc	TOY	Texas Instruments Inc.	TXN
Unisys Corp	UIS	Williams Cos Inc.	WMB
Verizon Communications	VZ	Wal-Mart Stores	WMT
Weyerhaeuser Co.	WY	Xerox Corp	XRX

Table 16 shows the descriptive statistics of the annual buy-and-hold stock returns of growth and value portfolios classified by price-to-book and price-to-earning.

Table 16:

Descriptive Analysis of the Annual Buy-and-Hold Stock Return of Value and Growth Portfolios over the Sample Period from 2000 to 2002

(E) represents the summary of equally-weighted series, and (V) represents the summary of value-weighted series. Sample size is 636 observations for each time series.

Sample Period	Growth Portfolio		Value Portfolio	
Classified by Price-to-Book Ratio				
	(E)	**(V)**	**(E)**	**(V)**
Whole Period	-0.2978	-0.4411	-0.1402	-0.2214
2000	0.0259	-0.0124	-0.0412	-0.0582
2001	-0.1804	-0.2013	0.0511	0.0526
2002	-0.1516	-0.1537	-0.1368	-0.1486
Classified by Price-to-Earning Ratio				
	(E)	**(V)**	**(E)**	**(V)**
Whole Period	-0.3006	-0.4558	-0.2220	-0.4392
2000	0.0076	-0.0592	-0.1001	-0.2659
2001	-0.1493	-0.1756	0.0346	-0.0593
2002	-0.1904	-0.2774	-0.1601	-0.1979

Overall, the buy-and-hold return of value stocks is higher than that of growth stocks for both the equally weighted and the value-weighted portfolios over the sample period from 2000 to 2002, even though both portfolios report negative returns. There is evidence of value effects.

For the portfolios formed by price-to-book ratio, the buy-and-hold return of equally-weighted value and growth portfolios is -0.2978 and -0.1402, respectively. With growth portfolio earning an annual return of 0.0259 in 2000, the beginning of a market decline, value portfolio provides -0.0124. However, in the later periods 2001 and 2002 the value stocks outperform growth stocks. In particular, the value portfolio has a buy-and-hold return of 0.0511 in 2001 whereas the growth portfolio reports a return of -0.1804. For the value-weighted portfolios, value portfolios consistently show a higher buy-and-hold return than the growth portfolios, even though the return of both is negative for the whole sample period from 2000 to 2002. Decomposing the sample by year, I find out that the value portfolio outperforms growth portfolio in 2001 and 2002, while the reverse holds true for 2000.

For the portfolios classified by price-to-earning ratio, the value portfolio outperforms the growth portfolio over the whole sample period from 2000 to 2002. The difference in buy-and-hold return between growth portfolio and value portfolio is larger for the equally-weighted portfolios than for the value-weighted. While the equally-weighted growth portfolio reports a buy-and-hold return of -0.3006, the value portfolio reports -0.2220. Similar to the case of portfolios based on price-to-book ratio, the growth portfolio outperforms the value portfolio in 2000, and the reverse holds for 2001 and 2002.

Table 17 shows the descriptive analysis of the short-term and long-term series of value and growth portfolios for the whole sample period from 2000 to 2002 and for each year.

Table 17:

Descriptive Analysis of the Implied Volatility of Short-term and Long-term Option Series of Value and Growth Portfolios over the Sample Period from 2000 to 2002

(S) represents the summary of short-term series of option contracts, and (L) represents the summary of long-term series of option contracts. Sample size is 636 observations for each time series.

Sample Period	Mean	Median	Standard Deviation	Minimum	Maximum
Portfolios Formed by Price-to-Book Ratios					
Equally-weighted Value Portfolio:					
Full Sample					
(S)	0.6297	0.6315	0.0964	0.4213	0.8757
(L)	0.5359	0.5313	0.0646	0.4131	0.7645
2000					
(S)	0.6072	0.6021	0.0950	0.4312	0.8404
(L)	0.5267	0.5137	0.0576	0.4350	0.6736
2001					
(S)	0.6877	0.6878	0.0741	0.5261	0.8757
(L)	0.5645	0.5630	0.0685	0.4391	0.7645
2002					
(S)	0.5824	0.6014	0.0863	0.4213	0.7515
(L)	0.5116	0.5133	0.0517	0.4131	0.6441
Equally-weighted Growth Portfolio:					
Full Sample					
(S)	0.5890	0.5475	0.1325	0.3409	1.1599
(L)	0.5279	0.5268	0.0785	0.3407	0.7474
2000					
(S)	0.5914	0.5701	0.1087	0.4576	1.0324
(L)	0.5287	0.5242	0.0575	0.4360	0.6694
2001					
(S)	0.6184	0.5958	0.1570	0.3409	1.1599
(L)	0.5424	0.5378	0.0894	0.3407	0.7474
2002					
(S)	0.5585	0.5430	0.1082	0.3714	0.8984
(L)	0.5132	0.5214	0.0735	0.3705	0.7002

Table 17: (Continued)

Descriptive Analysis of the Implied Volatility of Short-term and Long-term Option Series of Value and Growth Portfolios over the Sample Period from 2000 to 2002

(S) represents the summary of short-term series of option contracts, and (L) represents the summary of long-term series of option contracts. Sample size is 636 observations for each time series.

Sample Period	Mean	Median	Standard Deviation	Minimum	Maximum
Portfolios Formed by Price-to-Book Ratios					
Value-weighted Value Portfolio:					
Full Sample					
(S)	0.6201	0.6362	0.1425	0.2989	0.9933
(L)	0.5098	0.5122	0.0988	0.3012	0.7817
2000					
(S)	0.6098	0.6233	0.1274	0.4012	0.8712
(L)	0.5052	0.4907	0.0877	0.3573	0.6979
2001					
(S)	0.7262	0.7355	0.0099	0.4439	0.9933
(L)	0.5673	0.5605	0.0837	0.4012	0.7817
2002					
(S)	0.5192	0.4936	0.1063	0.2989	0.7522
(L)	0.4546	0.4502	0.0851	0.3012	0.6522
Value-weighted Growth Portfolio:					
Full Sample					
(S)	0.5648	0.5516	0.0869	0.3415	0.8996
(L)	0.4585	0.4534	0.0577	0.3198	0.6656
2000					
(S)	0.5804	0.5486	0.0893	0.4681	0.8434
(L)	0.4584	0.4517	0.0442	0.3968	0.5763
2001					
(S)	0.5795	0.5725	0.0991	0.3796	0.8996
(L)	0.4697	0.4587	0.0723	0.3534	0.6656
2002					
(S)	0.5423	0.5465	0.0656	0.3451	0.6981
(L)	0.4474	0.4484	0.0436	0.3198	0.5389

Table 17: (Continued)

Descriptive Analysis of the Implied Volatility of Short-term and Long-term Option Series of Value and Growth Portfolios over the Sample Period from 2000 to 2002

(S) represents the summary of short-term series of option contracts, and (L) represents the summary of long-term series of option contracts. Sample size is 636 observations for each time series.

Sample Period	Mean	Median	Standard Deviation	Minimum	Maximum
Portfolios Formed by Price-to-Earning Ratios					
Equally-weighted Value Portfolio:					
Full Sample					
(S)	0.6407	0.6457	0.1237	0.4022	0.9984
(L)	0.4966	0.4989	0.0546	0.3585	0.7464
2000					
(S)	0.6229	0.6026	0.1048	0.4312	0.8824
(L)	0.5142	0.5125	0.0379	0.4216	0.6315
2001					
(S)	0.7173	0.7215	0.0965	0.4316	0.9984
(L)	0.5130	0.5151	0.0464	0.4068	0.7464
2002					
(S)	0.5726	0.5312	0.1135	0.4022	0.8915
(L)	0.4714	0.4611	0.0595	0.3585	0.6963
Equally-weighted Growth Portfolio:					
Full Sample					
(S)	0.5401	0.5367	0.0817	0.4138	0.8016
(L)	0.4859	0.4785	0.0549	0.3978	0.6336
2000					
(S)	0.5855	0.4785	0.0846	0.4773	0.8455
(L)	0.4981	0.4986	0.0487	0.3869	0.6652
2001					
(S)	0.5658	0.5779	0.0622	0.4315	0.7099
(L)	0.4875	0.4888	0.0419	0.3869	0.6012
2002					
(S)	0.5764	0.5757	0.0859	0.4138	0.8455
(L)	0.4956	0.4971	0.0502	0.3869	0.6652

Table 17: (Continued)

Descriptive Analysis of the Implied Volatility of Short-term and Long-term Option Series of Value and Growth Portfolios over the Sample Period from 2000 to 2002

(S) represents the summary of short-term series of option contracts, and (L) represents the summary of long-term series of option contracts. Sample size is 636 observations for each time series.

Sample Period	Mean	Median	Standard Deviation	Minimum	Maximum
Portfolios Formed by Price-to-Earning Ratios					
Value-weighted Value Portfolio:					
Full Sample					
(S)	0.6742	0.6665	0.1128	0.4171	1.2022
(L)	0.5195	0.5137	0.0703	0.3948	0.7675
2000					
(S)	0.6034	0.5970	0.0910	0.4171	0.8787
(L)	0.4777	0.4764	0.0653	0.3948	0.6937
2001					
(S)	0.6775	0.6661	0.1325	0.4660	1.2022
(L)	0.5547	0.5352	0.0774	0.4384	0.7675
2002					
(S)	0.7060	0.7121	0.0821	0.5600	0.9127
(L)	0.5052	0.5144	0.0443	0.4029	0.6395
Value-weighted Growth Portfolio:					
Full Sample					
(S)	0.5937	0.5845	0.1204	0.3751	0.9642
(L)	0.5236	0.5201	0.0823	0.3502	0.7437
2000					
(S)	0.6726	0.6732	0.0781	0.5121	0.8215
(L)	0.6117	0.6169	0.0611	0.4988	0.7437
2001					
(S)	0.6393	0.6456	0.1133	0.4415	0.9642
(L)	0.5488	0.5514	0.0590	0.4121	0.6893
2002					
(S)	0.5079	0.4875	0.0888	0.3751	0.7979
(L)	0.4538	0.4547	0.0472	0.3502	0.5937

The following five statistics of mean, median, standard deviation, minimum, and maximum of implied volatilities are reported. The level of long-term implied volatility is shown to be lower than the level of short-term implied volatility. The mean and median of the implied volatilities of the value portfolio are overall higher than those of growth portfolio for both short-term and long-term series. For the portfolios formed by price-to-book ratio, the mean and median of the implied volatilities are not very close between the equally-weighted and the value-weighted portfolios. For the whole period from 2000 to 2002, the mean short-term implied volatility of the equally-weighted value portfolio is 62.97%, whereas the growth portfolio is 58.90%. The average long-term implied volatility is lower than the average short-term implied volatility, 53.59% and 52.79% for value and growth portfolios respectively. For the portfolios formed by price-to-earning ratio, the value portfolios also report a higher mean and a higher median for the implied volatility than the growth portfolios do. The mean for the short-term implied volatility of the equally-weighted value and the growth portfolios is 64.07% and 54.01% respectively. Nevertheless, the difference of the average long-term implied volatility of the value and the growth portfolios is not significant, 49.66% and 54.01% respectively.

The daily changes in the implied volatility of both growth and value portfolios in 2001 are relatively high when comparing to 2000 and 2002. Because the stock market got volatile starting early 2000, the level of implied volatility is not vastly different between the value and growth portfolios.

V. 2 OLS Regression

Table 18 shows the results of OLS regressions of V_t^L against V_t^S to test whether the theoretical theta holds empirically, for the full sample period and for each year run separately.

Table 18:

Regressions of the Long-term Implied Volatility onto the Short-term Implied Volatility of Value and Growth Portfolios for the Sample Period from 2000 to 2002

$V_t^L = \alpha + \theta * V_t^S + \varepsilon$ Where V_t^L is the long-term implied volatility; V_t^S is the short-term implied volatility; α is the constant; θ is the coefficient; and ε is the error term. (E) represents the summary of equally-weighted series, and (V) represents the summary of value-weighted series. Sample size is 636 observations for each time series.

Sample Period	Constant	Coefficient	T-Statistics	Adjusted R^2
Classified by Price-to-Book Ratio				
Value Portfolio:				
Full Sample				
(E)	0.203	0.528	32.560	0.621
(V)	0.144	0.417	23.973	0.475
2000				
(E)	0.201	0.536	21.180	0.672
(V)	0.170	0.449	14.789	0.357
2001				
(E)	0.168	0.577	12.690	0.583
(V)	0.143	0.461	15.258	0.452
2002				
(E)	0.214	0.511	26.010	0.576
(V)	0.111	0.463	16.030	0.483
Growth Portfolio:				
Full Sample				
(E)	0.134	0.580	51.933	0.810
(V)	0.152	0.542	36.130	0.673
2000				
(E)	0.140	0.558	24.431	0.587
(V)	0.273	0.319	18.340	0.612
2001				
(E)	0.135	0.578	26.020	0.685
(V)	0.108	0.624	32.512	0.594
2002				
(E)	0.128	0.606	30.153	0.784
(V)	0.142	0.560	25.112	0.648

Table 18: (Continued)

Regressions of the Long-term Implied Volatility onto the Short-term Implied Volatility of Value and Growth Portfolios for the Sample Period from 2000 to 2002

$V_t^L = \alpha + \theta * V_t^S + \varepsilon$ Where V_t^L is the long-term implied volatility; V_t^S is the short-term implied volatility; α is the constant; θ is the coefficient; and ε is the error term. (E) represents the summary of equally-weighted series, and (V) represents the summary of value-weighted series. Sample size is 636 observations for each time series.

Sample Period	Constant	Coefficient θ	T-Statistics	Adjusted R^2
Classified by Price-to-Earning Ratio				
Value Portfolio:				
Full Sample				
(E)	0.287	0.328	27.889	0.551
(V)	0.195	0.454	34.780	0.657
2000				
(E)	0.353	0.259	11.470	0.432
(V)	0.328	0.322	12.190	0.512
2001				
(E)	0.228	0.426	14.980	0.578
(V)	0.309	0.465	15.020	0.635
2002				
(E)	0.294	0.306	11.910	0.514
(V)	0.254	0.363	12.020	0.638
Growth Portfolio:				
Full Sample				
(E)	0.204	0.503	37.840	0.693
(V)	0.112	0.651	38.520	0.701
2000				
(E)	0.237	0.449	23.970	0.712
(V)	0.141	0.585	28.740	0.638
2001				
(E)	0.163	0.582	15.780	0.695
(V)	0.128	0.654	21.550	0.717
2002				
(E)	0.161	0.580	25.300	0.521
(V)	0.165	0.543	23.470	0.468

The parameter of V_t^S indicates the empirical theta, the extent to which the long-term options react to the short-term options. If the parameter is 0.5, when the implied volatility of short-term option changes by 1% the implied volatility of long-term option would change by 0.5%. For the full sample period from 2000 to 2002, the evidence on portfolios formed by price-to-book and price-to-earning provides consistent results that the growth portfolios tend to have higher empirical thetas than the value portfolios.

For the full sample period, the portfolios of the equally-weighted growth portfolio and the value portfolio, which are formed by the price-to-book ratio, have the coefficients of 0.580 and 0.528, respectively. The difference of the coefficients of the value-weighted value portfolio and the growth portfolio is larger, with 0.542 and 0.417 respectively. The long-term option series overreacts to short-term series for both value and growth portfolios. Since the coefficients for the growth portfolios are relatively large in comparison to the value portfolios, the growth investors overreact to a greater degree than value investors. Decomposing the sample by year, the equally-weighted value portfolio reports the highest empirical theta of 0.577 in 2001, comparing to 0.536, and 0.511 in 2000 and 2002 respectively. The equally-weighted growth portfolio has relatively high coefficients every year with the highest in 2002 at 0.606, and 0.558 and 0.578 in 2000 and 2001 respectively.

For the full sample period, the portfolios formed by the price-to-earning ratio, the equally-weighted growth portfolio has a empirical theta of 0.503 in comparison with 0.328 for the value portfolio for the whole sample period. The value-weighted growth portfolio reports a coefficient of 0.651 and value portfolio shows only 0.454. The vast difference between empirical theta of the growth and the value portfolios suggests that there is fundamental difference between the value investors and the growth investors as reflected by their reaction to market volatility changes. Decomposed by year, both the equally-weighted and the value-weighted growth and value portfolios have the highest coefficients in 2001.

The θ coefficients of the equally-weighted growth and the value portfolios are 0.582 and 0.426 respectively, and those of the value-weighted growth and the value portfolios are 0.654 and 0.465 respectively.

V. 3 Test of Significance of Across Value and Growth Portfolios

To have a comprehensive investigation on whether the degree of overreaction of growth stocks is higher than that of the value stocks, I apply different stock volatility models and estimate parameters needed for the calculation of theoretical implied volatility of the growth and the value portfolios.

V.3.1. Derivation of Parameters

Assuming the stochastic process of implied volatility follows a mean reversion process decaying geometrically back to its long-term mean, the serial correlation properties of the instantaneous volatility σ_t are of interest to derive theoretical upper bounds for the elasticity of long-term implied volatility with respect to short-term implied volatility. The estimates of ρ at 4 days lag for the equally-weighted and the value-weighted value and growth portfolios are listed in Table 19.

The equally-weighted and value-weighted portfolios exhibit similar value of autocorrelation coefficients. However, the magnitude of autocorrelation differs between the growth and the value portfolios. For the portfolios classified by price-to-book ratio, the value portfolio represents higher autocorrelation of 0.942, than the growth of 0.897 for the equally-weighted portfolios. For the portfolios classified by price-to-earning ratio, the growth portfolio has an autocorrelation of 0.935, whereas value portfolio has 0.888 for the equally-weighted portfolios.

Table 19:

Autocorrelation and Partial Correlation Coefficients for the Implied Volatility of Short-Term Option Series of Value and Growth Portfolios for the Sample Period from 2000 to 2002

Implied daily ρ is the autocorrelation raised to the 1/n power, where n is the lag length in days. Sample size is 636 observations for each time series.

Lag length (days)		Autocorrelation	Partial Correlation	Implied daily ρ
Classified by Price-to-Book Ratio				
Value Portfolio:				
1	(E)	0.942 (0.040)	0.942 (0.040)	0.942
	(V)	0.953 (0.040)	0.953 (0.040)	0.953
2	(E)	0.897 (0.040)	0.088 (0.040)	0.947
	(V)	0.915 (0.040)	0.064 (0.040)	0.957
3	(E)	0.854 (0.040)	-0.002 (0.040)	0.949
	(V)	0.881 (0.040)	0.038 (0.040)	0.959
4	(E)	0.814 (0.039)	0.014 (0.040)	0.950
	(V)	0.855 (0.039)	0.084 (0.040)	0.962
Growth Portfolio:				
1	(E)	0.897 (0.040)	0.897 (0.040)	0.897
	(V)	0.898 (0.040)	0.898 (0.040)	0.898
2	(E)	0.751 (0.040)	-0.280 (0.040)	0.867
	(V)	0.823 (0.040)	0.084 (0.040)	0.907
3	(E)	0.624 (0.040)	0.067 (0.040)	0.855
	(V)	0.754 (0.040)	0.009 (0.040)	0.910
4	(E)	0.509 (0.039)	-0.062 (0.040)	0.845
	(V)	0.682 (0.040)	-0.045 (0.040)	0.909

Table 19: (Continued)

Autocorrelation and Partial Correlation Coefficients for the Implied Volatility of Short-Term Option Series of Value and Growth Portfolios for the Sample Period from 2000 to 2002

Implied daily ρ is the autocorrelation raised to the 1/n power, where n is the lag length in days. Sample size is 636 observations for each time series.

Lag length (days)		Autocorrelation	Partial Correlation	Implied daily ρ
Classified by Price-to-Earning Ratio				
Value Portfolio:				
1	(E)	0.888 (0.040)	0.888 (0.040)	0.888
	(V)	0.825 (0.040)	0.825 (0.040)	0.825
2	(E)	0.827 (0.040)	0.180 (0.040)	0.942
	(V)	0.794 (0.040)	0.354 (0.040)	0.891
3	(E)	0.772 (0.040)	0.048 (0.040)	0.917
	(V)	0.754 (0.040)	0.138 (0.040)	0.910
4	(E)	0.724 (0.039)	0.028 (0.040)	0.922
	(V)	0.718 (0.039)	0.062 (0.040)	0.921
Growth Portfolio:				
1	(E)	0.935 (0.040)	0.935 (0.040)	0.935
	(V)	0.929 (0.040)	0.929 (0.040)	0.929
2	(E)	0.852 (0.040)	-0.172 (0.040)	0.923
	(V)	0.878 (0.040)	0.112 (0.040)	0.937
3	(E)	0.762 (0.040)	-0.083 (0.040)	0.913
	(V)	0.831 (0.040)	0.023 (0.040)	0.940
4	(E)	0.676 (0.039)	-0.011 (0.040)	0.907
	(V)	0.785 (0.040)	-0.007 (0.040)	0.941

Using the daily stock returns of each portfolio classified by price-to-book and price-to-earning ratios separately, I assume stock fluctuation specified by GARCH (1,2) model and estimate $\alpha_0, \alpha_1,$ and α_2 in Equation (7) to derive the unconditional variance $\overline{\sigma}^2$ and to estimate the theoretical theta. The parameter estimates of the GARCH (1,2) and the value of

ɣ are reported in Table 20. The value and the growth portfolios have the values of ɣ varying within the range from 0.7865 to 0.9102.

Table 20:

Stock Return Test Statistics for a GARCH (1,2) Specification over the Sample Period from 2000 to 2002

$$R_t = r + \lambda\sigma_t - \frac{1}{2}\sigma_t^2 + \varepsilon_t + \beta\varepsilon_{t-1}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \alpha_2\sigma_{t-1}^2 + \alpha_3\varepsilon_{t-1}^2$$

Where R_t is the daily stock return, σ_t is the stock volatility, r is the risk-free rate, λ is the unit risk premium, $\alpha_0, \alpha_1,$ and α_2 are independent parameters, and ε_t is Gaussian white noise. (E) represents the equally-weighted option series, whereas (V) represents value-weighted option series. Sample size is 636 observations for each time series.

Portfolios Classified by Price-to-Book Ratio:

	Growth Portfolio		**Value Portfolio**	
	(E)	(V)	(E)	(V)
α_0	0.00005	0.00002	0.00003	0.00004
α_1	0.1197	0.1145	0.1666	0.1798
α_2	0.7472	0.7752	0.7138	0.7304
α_3	-0.0012	-0.1528	0.1575	-0.1698
$\alpha_1+\alpha_1$	0.8669	0.8897	0.8804	0.9102

Portfolios Classified by Price-to-Earning Ratio:

	Growth Portfolio		**Value Portfolio**	
	(E)	(V)	(E)	(V)
α_0	0.00001	0.00001	0.00003	0.00004
α_1	0.0090	0.0109	0.0766	0.1056
α_2	0.8704	0.8820	0.7099	0.7499
α_3	0.0958	0.0763	0.0931	-0.1966
$\alpha_1+\alpha_1$	0.8794	0.8929	0.7865	0.8555

The parameter estimates of EGARCH (1,1) models for the equally-weighted and value-weighted growth and the value portfolios are reported in Table 21.

Table 21:

Stock Return Test Statistics for an EGARCH (1,1) Specification over the Sample Period from 2000 to 2002

$$R_t = r + \lambda\sigma_t - \frac{1}{2}\sigma_t^2 + \sigma_t\varepsilon_t$$

$$Ln\sigma^2 = \alpha_0 + \alpha_1 Ln\sigma_{t-1}^2 + \alpha_2\varepsilon_{t-1} + \alpha_3(|\varepsilon_{t-1}| - \sqrt{\frac{2}{\pi}})$$

Where R_t is the daily stock return, σ_t is the stock return volatility, $\alpha_0, \alpha_1, \alpha_2,$ and α_3 are independent parameters, and ε_t is Gaussian white noise. (E) represents the equally-weighted option series, whereas (V) represents value-weighted option series. Sample size is 636 observations for each time series.

Portfolio Classified by Price-to-Book Ratio:

	Growth Portfolio		Value Portfolio	
	(E)	(V)	(E)	(V)
α_0	-0.5967	-1.3484	-0.4808	-1.2173
α_1	0.9493	0.8886	0.9201	0.8369
α_2	0.2683	0.2607	0.6123	-0.0045
α_3	-0.0704	-0.0618	0.0204	-0.2787

Portfolio Classified by Price-to-Earning Ratio:

	Growth Portfolio		Value Portfolio	
	(E)	(V)	(E)	(V)
α_0	-0.3009	-0.2790	-0.3491	-1.2903
α_1	0.9594	0.8703	0.9547	0.7840
α_2	0.0474	0.0418	0.0697	0.1801
α_3	-0.1595	-0.1809	-0.1603	-0.1672

α_1 is the key parameter that makes the theoretical theta different from that estimated under other specifications. Among all portfolios, the α_1 estimates for the growth portfolio are slightly higher than the estimates for the value portfolio. For the portfolios formed by price-to-book ratio, α_1 equals to 0.9493 and 0.9201 for the equally-weighted growth and the value portfolios respectively, and 0.8886 and 0.8369 for the value-weighted portfolios respectively. The α_1 estimates of portfolios classified by price-to-book ratio follow the similar pattern. The equally-weighted growth portfolio and the value portfolio report the value of α_1, 0.9594 and 0.9547 respectively, while the value-weighted growth and the value portfolio show 0.8703 and 0.7840 respectively.

As shown in Equation 15, the theoretical theta depends on both the decay parameter p and the time to expiration T of the short-term option series. Thus, theoretical theta varies over a range of values as p changes. The possible theoretical thetas for different p are calculated and presented in Table 22.

Table 22:

Theoretical Value of $\theta(p,T) = \dfrac{T(p^{T+n}-1)}{(T+n)(p^{T}-1)}$

θ represents the theoretical elasticity of the implied volatility of long-term options with respect to that of the short-term options. p is the parameter estimate under different stock specifications. T is the time to expiration of the short-term option, and the time to expiration of the long-term option is n days longer than T. (n=30 days for the Table)

T = No. of days	p=0.7	p=0.8	p=0.9	p=0.95
5	0.1717	0.2124	0.3401	0.5266
10	0.2573	0.2800	0.3782	0.5430
15	0.3349	0.3455	0.4161	0.5593
20	0.4003	0.4047	0.4530	0.5755
25	0.4546	0.4563	0.4882	0.5916
29	0.5000	0.5006	0.5212	0.6042

Four p values and six possible terms to expiration ranging from 5 days to 30 days are used to calculate the theoretical theta. As the long-term option series in the study has one month longer time to expiration than the short-term series, the theoretical theta value ranges from 0.1768 to 0.6042, getting larger as p gets larger given the same time to expiration. For example, when p is 0.9 and the short-term option contract has 30 days to expiration, the theoretical value of theta is 0.5212. If the long-term options of a stock are priced rationally relative to the short-term options, then when the short-term volatility is one point above its mean, the long-term implied volatility should be at most about 0.5212 percent above its mean. Different p values under mean reversion, GARCH and EGARCH models are listed in Table 23.

Table 23:

Parameter Values under Different Stock Specifications for Value and Growth Portfolios for the Sample Period from 2000 to 2002

Theoretical value of elasticity of long-term implied volatilities relative to short-term implied volatilities is theta, $\theta(p,T) = \frac{T(p^{T+n}-1)}{(T+n)(p^{T}-1)}$. p is the parameter estimate under different stock volatility specifications. (E) represents the equally-weighted option series, whereas (V) represents value-weighted option series. Sample size is 636 observations for each time series.

Portfolio Classified by Price-to-Book Ratio:

	Growth Portfolio		Value Portfolio	
	(E)	(V)	(E)	(V)
Mean Reversion	0.897	0.898	0.942	0.953
GARCH	0.867	0.889	0.880	0.910
EGARCH	0.949	0.889	0.920	0.837

Portfolio Classified by Price-to-Earning Ratio:

	Growth Portfolio		Value Portfolio	
	(E)	(V)	(E)	(V)
Mean Reversion	0.935	0.929	0.888	0.825
GARCH	0.879	0.893	0.787	0.856
EGARCH	0.959	0.870	0.955	0.784

T tests in Table 24 enhance the regression results by comparing the daily actual long-term implied volatility with the expected long-term implied volatility based on theoretical theta for the growth portfolios and the value portfolios to see whether there is a significant difference in the degree of overreaction between the two portfolios.

Table 24:

T-tests of the Difference between Value Portfolios and Growth Portfolios on the Mean Difference between the Actual and the Expected Long-Term Implied Volatility for the Sample Period from 2000 to 2002

The table shows the mean difference between the actual and the expected long-term implied volatility for each portfolio. The expected long-term volatility is calculated based on the theoretical theta $\theta(p,T) = \frac{T(p^{T+n}-1)}{(T+n)(p^{T}-1)}.\theta(p,T)$ represents the theoretical elasticity of the implied volatility of long-term options with respect to that of the short-term options. p is the parameter estimate under different stock specifications. T is the time to expiration of the short-term option, and the time to expiration of the long-term option is n days longer than T. (E) represents the equally-weighted option series, whereas (V) represents the value-weighted option series. Sample size is 636 observations for each time series. ***, * represent the 1% and 10% level of significance respectively.

Models	Growth Portfolio	Value Portfolio	Difference	T-Stat
Classified by Price-to-Book Ratio:				
Mean Reversion				
(E)	0.049	0.027	0.022	5.481***
(V)	0.011	0.004	0.007	0.852
GARCH				
(E)	0.021	0.014	0.007	1.819*
(V)	0.006	0.021	-0.015	-1.818*
EGARCH				
(E)	0.083	0.045	0.038	7.988***
(V)	0.046	0.073	-0.027	-3.110***
Classified by Price-to-Earning Ratio:				
Mean Reversion				
(E)	0.026	0.008	0.018	2.840***
(V)	0.020	-0.004	0.024	2.445***
GARCH				
(E)	0.040	0.041	-0.001	-0.095
(V)	0.028	0.005	0.023	2.340***
EGARCH				
(E)	0.036	0.032	0.004	0.440
(V)	0.017	-0.006	0.023	2.558***

The mean difference between the actual and the expected long-term implied volatility for each portfolio indicates the degree of overreaction of long-term options in respect to short-term options. The mean difference is positive for both the growth and the value portfolios formed by price to book ratio. However, when mean reversion and EGARCH models are applied to the stock volatility, the two value portfolios formed by price to earnings show negative mean differences, indicating that the average empirical long-term implied volatility is not higher than the theoretical one. The significance of T-values shows the extent to which the growth portfolio is different from the value portfolio in terms of the degree of overreaction of long-term options in respect to short-term options. The higher the T-values, the larger the degree of overreaction the growth portfolios have than the value portfolios.

V.3.2 Evidence on the Portfolios Formed by Price-to-Book Ratio

For the portfolios formed by price-to-book ratio, the degree of overreaction of the equally weighted growth portfolios is significantly higher than that of the equally weighted value portfolios under different stock specifications. When implied volatility is assumed to revert to the mean level, the mean difference between the empirical long-term implied volatility and the theoretical long-term implied volatility of the growth portfolio is significantly higher than that of the value portfolio, with a T-value of 5.481, significant at the 1% level of significance. Assuming the stock volatility is specified by GARCH (1,2) model, the error between the empirical value and the theoretical value is significantly higher for the growth portfolios than for the value portfolios at the 10% level of significance. For the EGARCH specifications, the equally-weighted growth portfolios also show a higher degree of overreaction as the T-value is 7.988, significant at the 1% level of significance.

For the value-weighted portfolios, the growth portfolios do not overreact significantly to a larger degree than the value portfolios. In contrast, when the GARCH (1,2) and the

EGARCH (1,1) stock specifications are assumed, the value portfolios tend to overreact to a larger degree with T-values of 1.818 and 3.110, significant at the 1% and the 10% levels of significance respectively. However, when mean reversion is assumed, the mean difference between the empirical long-term implied volatility and the theoretical long-term implied volatility of the growth portfolios is higher, though not significantly higher, than that of the value portfolios. This implies that the relatively large degree of overreaction of the growth portfolios might be the results of the overreaction of some small growth stocks in the value-weighted growth portfolios.

V.3.3 Evidence on the Portfolios Formed by Price-to-Earning Ratio

For the portfolios formed by price-to-earning ratio, the difference between the empirical long-term implied volatility and the theoretical long-term implied volatility of the equally-weighted growth portfolios is significantly higher than that of the equally-weighted value portfolios under mean reversion specification at the 1% level of significance, indicating a greater degree of overreaction. However, When GARCH and EGARCH models are assumed for stock volatility, the difference between the growth and the value portfolios is not significant. For the comparison between the value-weighted growth and the value portfolios, the mean reversion, GARCH, and EGARCH models consistently report T-values of 2.445, 2.340, and 2.558 respectively, significant at the 5% level of significance.

Overall, the empirical results on the growth and the value portfolios built by different criteria show that the degree of overreaction of long-term options in respect to short-term options of the growth portfolios is higher than that of the value portfolios. While most of the value portfolios overreact, there are a few exceptions that long-term options of the value portfolios classified by price-to-earning ratio are shown not to overreact. Among twelve comparisons between the growth and the value portfolios across different specifications of

stock movements, the growth portfolios largely overreact to a larger degree than the value portfolios, consistent with overreaction as an explanation to the value effect.

VI. CONCLUSIONS

Using the up-to-date option data from the Prophet Financial Systems from 2000 to 2002, I investigate whether the growth investors overreact to a larger degree than the value investors by Stein's (1989) mean reversion model and Heynen, Kemna, and Vorst's (1994) GARCH and EGARCH methods. To check for robustness, I form portfolios by price-to-book and price-to-earning ratios and obtain the time series data on both the equally-weighted and the value-weighted basis. The value and the growth portfolios taken from Standard & Poor's 100 stocks show that the growth investors largely overreact to a larger degree than the value investors.

The empirical results from the comparison of the degree of the overreactions between the value and the growth portfolios using implied volatility from option prices contributes to the existing literature as a support to overreaction as an explanation to the value effect. Investors holding different portfolios are fundamentally different and have different expectations on the future volatility of the portfolios. This implies that investors are not well diversified, and instead overreact more to news for growth stocks than for value stocks.

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Vita

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