NBER WORKING PAPER SERIES

PHARMACEUTICAL STOCK PRICE REACTIONS TO PRICE CONSTRAINT THREATS AND FIRM-LEVEL R&D SPENDING

Joseph Golec
Shantaram Hegde
John Vernon

Working Paper 11229
http://www.nber.org/papers/w11229

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2005

We are very grateful to a the following individuals for their very helpful comments and suggestions on earlier versions of this paper: Ernest Berndt, Jean Paul Gagnon, Carmelo Giaccotto, Richard Manning, Sean Nicholson, Rexford Santerre, John M. Vernon, Y. Richard Wang and participants at the 2005 AEA/PEPC meetings in Philadelphia. We thank AstraZeneca and the Center for International Business & Education Research at the University of Connecticut for financial support. All errors are our own. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

Pharmaceutical Stock Price Reactions to Price Constriant Threats and Firm-Level R&D Spending
Joseph Golec, Shantaram Hegde, and John Vernon
NBER Working Paper No. 11229
March 2005
JEL No. G31, O32, L65, I1, K2

ABSTRACT

Political pressure in the United States is again building to constrain pharmaceutical prices either directly or through legalized reimportation of lower-priced pharmaceuticals from foreign countries. This study uses the Clinton Administration's Health Security Act (HSA) of 1993 as a natural experiment to show how threats of price constraints affect firm-level R&D spending. We link events surrounding the HSA to pharmaceutical company stock price changes and then examine the cross-sectional relation between the stock price changes and subsequent unexpected R&D spending changes. Results show that the HSA had significant negative effects on firm stock prices and R&D spending. Conservatively, the HSA reduced R&D spending by $1.6 billion, even though it never became law. If the HSA had passed, and had many small firms not raised capital just prior to the HSA, the R&D effects could have been much larger.

Joseph Golec
University of Connecticut
Department of Finance
2100 Hillside Road
Storrs, CT 06269
jgolec@business.uconn.edu

Shantaram Hegde
University of Connecticut
Department of Finance
2100 Hillside Road
Storrs, CT 06269
shegde@business.uconn.edu

John Vernon
University of Connecticut
Department of Finance
2100 Hillside Road
Storrs, CT 06269
and NBER
jvernon@business.uconn.edu

1. Introduction

Do public policies that affect firms' product pricing or profitability affect their research and development (R&D) spending decisions? In one of the few studies of this issue, Finkelstein (2004) shows that policies designed to boost particular vaccines' profitability lead to greater R&D spending on those vaccines. The current debate over general pharmaceutical price constraint policies, such as drug reimportation, has given little consideration to the potential effects of such a policy on R&D spending. Our study adds to this debate by examining the effects that pharmaceutical price constraints proposed by the Clinton Administration's Health Security Act (HSA) had on firm-level R&D spending.

The debate over whether pharmaceutical price constraints will negatively affect R&D spending is not as one-sided as one might think. Ellison and Mullin (2001) suggest that the HSA caused a pure wealth transfer from pharmaceutical firms to consumers, and that R&D spending might not be affected. Sager and Socolar (2004) argue that lower pharmaceutical prices would not affect firms' profits, so that R&D spending would not be affected. But other studies suggest that, at least at the industry-level, policies designed to lower pharmaceutical prices will lead to lower R&D spending (Scherer, 2001, Vernon, 2005, 2003, and Giaccotto, Santerre, and Vernon, 2005).

The HSA ultimately was not adopted, but the political debate surrounding it was ferocious during 1993, and its seeds were planted during the general healthcare reform debate of the 1992 presidential campaign. This political debate coincided with extremely poor stock returns for pharmaceutical firms. Ellison and Mullin's (2001) sample of 18 large pharmaceutical company stocks experienced an average loss of 38 percent during 1992-1993. We find similar negative returns, but for a wider variety of 111 pharmaceutical and biotechnology companies. More important, we show that the higher the R&D intensity, the larger the loss, with top quartile firms losing 60 percent on average.

We do not ascribe all of the cumulative declines in pharmaceutical stock prices during the long 1992-1993 period to threatened price regulation, although this may very well be the case. Instead, we use the combined effects of a few events most closely linked to the pharmaceutical pricing threats as a proxy variable to capture the stock market's assessment of the relative impact of potential price regulation across pharmaceutical firms. Then, we test to see if this proxy variable can explain the changes in firms' subsequent R&D spending.

But can we expect firms to change R&D spending just because their stock prices change? Durnev, Morck, and Yeung (2004) show that sharper changes in stock prices lead to sharper changes in investment. Hence, if the HSA caused the market to significantly revalue pharmaceutical R&D[1], it represents an excellent opportunity to observe whether firms responded by making significant changes in their R&D investment. Furthermore, relatively flexible R&D investments could be more responsive than other investments.

Lichtenberg (2004) uses a sample of 46 pharmaceutical firms to show a significant link between pharmaceutical stock price changes and R&D spending. He conjectures that pricing constraints proposed in the HSA during 1993 could have caused the significant declines in pharmaceutical stock prices in 1993, and the significant declines in industry-level R&D spending growth in 1994 and 1995. But he does not link firms' stock returns in 1993 to their R&D spending in 1993, 1994, and 1995. This is our task.

The value of firms' R&D asset were most at risk from the HSA because it explicitly proposed limits on new breakthrough drug prices as opposed to currently-marketed drugs (Abbott, 1995). Therefore, we test whether R&D intensive firms (e.g., small biotechnology firms) experienced relatively large stock price changes and R&D spending changes.

[1] Chan, Lakonishok, and Sougiannis (2001) show that stock prices and stock returns accurately reflect the underlying value of firms' R&D assets even though firms account for R&D as an expense rather than a capital asset. Eberhart, Maxwell and Siddique (2004) suggest that unexpected changes in R&D are mispriced initially.

We also study the cross-sectional effects of the HSA on firm risk; both systematic and total risk. We examine how the levels (and changes) of firm risk during the period are related to their stock losses and subsequent R&D spending. Although price constraints probably reduce expected future profitability, they could also reduce expected future return volatility, as is common for price-regulated utilities. Of course, because the HSA was not enacted, the events surrounding it could have simply created greater uncertainty about future pharmaceutical prices, increasing firm risk.

We use a simple model to explain why price constraints could affect some firms' stock prices and R&D spending more than others. A firm's R&D assets are modeled as real options. Stock return risk levels (and changes) measure R&D leverage, which has implications for the value and sensitivity of firms' R&D options values. Therefore, the R&D leverage implied by a firm's risk level and risk change could also help to explain changes in its stock price and R&D spending.

Ellison and Wolfram (2001) show that 21 large pharmaceutical firms viewed the HSA as such a serious threat that they pledged to keep their price increases below consumer inflation. Their coordinated strategy to preempt the HSA was taken seriously by the Department of Justice (which ruled that it was illegal) and the Federal Trade Commission (which investigated the industry for price fixing). But these large firms are not necessarily the most R&D intensive. Our analysis shows that investors believed that R&D intensive firms would be the most negatively affected. We find that firms responded to declines in their stock prices by reducing their R&D intensities below expected levels. R&D intensity was lower by 8.3 percent in 1994, which is equivalent to a drop of $796 ($1.6 billion) million in R&D spending measured in 1983 (2004) dollars. If the HSA had passed, and had many smaller firms not raised significant amounts of capital just before the HSA[2], the change in R&D spending could have been much greater.

[2] A sharp drop in external financing available to these firms after the HSA, documented by Lerner, Shane, and Tsai (2003), is consistent with the relatively large declines in their stock prices.

This paper is organized as follows. Section 2 presents a simple model to describe the behavior of brand-name pharmaceutical firms, generic pharmaceutical firms, and pure research companies (e.g. biotech firms). Section 3 uses the model to explain the effects that the HSA could have on pharmaceutical firms' R&D investment behavior. Section 4 describes the data and presents a graphical view of the effects observed in the data. Section 5 provides statistical test results to decide if the relations observed in the data are statistically significant. Section 6 concludes the paper.

2. The Model

To simplify the presentation, assume that pharmaceutical firms are holding companies composed of two subsidiaries. The first one markets a drug that yields a given cash flow C, which grows at the rate g, for a period of τ years. Its cost of capital is k_D. The value of the drug marketing subsidiary, V_D, is

$$V_D = \frac{C(1+g)\left[1-\frac{(1+g)^{\tau}}{(1+k_D)^{\tau}}\right]}{k_D - g} \quad . \tag{1}$$

The second subsidiary manages the firm's potential research and development project. If it chooses to, it can spend E dollars on research and development expenses and receive a call option on the production of a new drug. The value of this R&D subsidiary, V_R, is

$$V_R = c(S, \sigma_s, X, T, r) - E, \tag{2}$$

where c(•) is a function defining the value of a call option on a new drug with an expected net present value of future cash flows of *S*, a percent volatility for *S* of σ_s, and a fixed investment cost to build a production plant of *X* at time *T* in the future. The risk-free rate of return is *r*.

The firm also holds net liquid assets, V_L, which are raised from investors or generated from marketed drugs. The value of the holding company is,

$$V_H = V_L + V_D + V_R \, . \tag{3}$$

The expected return of the holding company's stock (ignoring debt) is,

$$k_H = W_L \, k_L + W_D \, k_D + W_R \, k_R \, , \tag{4}$$

where $W_L = V_L/V_H$, $W_D = V_D/V_H$, $W_R = V_R/V_H$, and k_L, k_D, and k_R are the expected returns on liquid assets, marketed drug assets, and R&D assets, respectively.

The systematic risk (β_H) of the holding company is a weighted average of the Capital Asset Pricing Model (CAPM) betas of the three assets;

$$\beta_H = W_L \, \beta_L + W_D \, \beta_D + W_R \, \beta_R \, . \tag{5}$$

We assume that $\beta_L = 0$. β_D is likely to be smaller than β_R because the R&D drug involves a future payment for fixed costs of production facilities and product launch. This future payment is equivalent to financial leverage, which increases beta. Assuming that the firm's capital structure is constant over time, then $\beta_D < \beta_R$.

From this simple setup, we can distinguish among a wide range of pharmaceutical firms by referring to different weight combinations. Generic firms' research opportunities have

relatively small value, so that W_R is relatively small and W_D is relatively large. But even within this group, generic firms with larger growth rates (better products) will have larger W_D than other generics. Biotech companies with few current products can be characterized as having relatively large W_R and relatively small W_D. Many large established pharmaceutical firms will have more balanced weights. W_L could be roughly proportional to W_R. A large W_L implies liquid assets available to fund an intensive R&D program.

The model also helps to identify the firms whose stock and R&D decisions should be most sensitive to the HSA effects. Because the HSA sought to regulate *new* drug prices, R&D-intensive firms (large W_R) should be most affected, all else equal[3]. But this assumes a homogeneous distribution of R&D project characteristics across firms. In reality, some firms will have more marginal R&D projects that are more sensitive to the HSA.

One way to measure a particular firm's R&D sensitivity is to consider their stock risk and volatility from a real options perspective. First, marginal projects can be defined by the difference between the R&D asset value and the cost of production facilities, (S – X). That is, how far a project is "in-the-money." (S – X) should be negatively associated with β_R. Recall that the level of firm β_R (and in turn β_H) measures its R&D leverage. A firm composed of mostly at-the-money or out-of-the-money R&D projects should have a relatively high β_H, and be relatively sensitive to the effects of the HSA. Conversely, the level of asset volatility, measured by σ_s, implies larger R&D option values and less sensitivity to the HSA, all else equal[4].

The changes in risk and volatility can also help identify the most sensitive firms. Consider first how β_H should change due to the HSA. Using (5) and denoting the HSA price regulation effect as "p", the change in the holding company's beta is:

---

[3] V_R and W_R probably decline because a call option value declines with the underlying asset's value (S). S declines because expected drug revenues fall assuming inelastic demand (see Coulson and Stuart, 1995), while production costs stay constant. A capped price could be less volatile than a free-market price, leading to a less volatile underlying asset value. This reduced volatility also decreases the R&D call option value.

[4] Galai and Masulis (1976) show that option beta is negatively related to S and σ_s, and positively related to X.

$$\frac{\partial \beta_H}{\partial p} = W_L \frac{\partial \beta_L}{\partial p} + \frac{\partial W_L}{\partial p}\beta_L + W_D \frac{\partial \beta_D}{\partial p} + \frac{\partial W_D}{\partial p}\beta_D + W_R \frac{\partial \beta_R}{\partial p} + \frac{\partial W_R}{\partial p}\beta_R . \qquad (6)$$

Because $\beta_L = 0$ and does not change, the first two terms on the right-hand-side of (6) disappear. Similarly, the HSA should have little effect on β_D because currently marketed drug prices would not be regulated; therefore, the third term disappears. The fourth and sixth terms represent the effects on β_H when the relative values of the two subsidiaries change. Their combined effects on β_H are likely to be negative on net. To see this, recall that $\beta_R > \beta_D$. Because the regulation will negatively affect the R&D subsidiary's value, but have little effect on the marketing subsidiary's value, the weight on the marketing subsidiary will increase and the weight on the R&D subsidiary will decrease, therefore, $\frac{\partial W_D}{\partial p}\beta_D + \frac{\partial W_R}{\partial p}\beta_R < 0$. That is, the marketing (R&D) subsidiary's smaller (larger) beta is weighted more (less) so that the weighted average beta is smaller.

The fifth term in (6) represents the HSA's effect on the risk of the R&D subsidiary. There are two relevant effects derived for call options in Galai and Masulis (1976). First, price constraints will reduce R&D asset value (S), and this will decrease the call value and increase β_R. More important, for those firms where (S – X) is small, β_R should change the most. That is, the betas of the firms with the greatest R&D leverage (more marginal projects) should also have the largest β_R changes. The value of their R&D projects should fall the most, all else equal, and their R&D spending should fall the most (assuming that management responds to stock price changes).

Variation in W_L complicates a cross-sectional analysis. Two otherwise identical firms with significantly different W_L will have different β_H changes. The firm with the larger W_L will have a smaller β_H change and stock price change. That is, large liquid asset holdings cushion the

effects of the HSA on firm risk and stock price. Hence, our analysis may need to control for cross-sectional variation in W_L.

An analysis of the HSA-induced change in σ_s proceeds in the same way but has opposite implications. If the HSA increases σ_s, the R&D asset value increases, all else equal. However, price regulation, such as that for electric utilities, usually leads to lower but less volatile prices. In any case, HSA-induced stock price change and R&D change should be positively related to the change in σ_s.

3. Expected effects of the HSA on firm value and risk

This section proposes two empirical models based upon the discussion above. The first tests whether investors impounded the expected effects of the HSA into firm market values. The second tests whether managers reacted to HSA-induced market value changes by changing R&D spending.

How should pharmaceutical firm market values change in response to the HSA? We propose the following model to explain the cross-section of market value reactions.

$$\text{HSA-R}_i = b_0 + b_1(\text{ERDTA}_{i,t}) + b_2(\beta_{H,i}) + b_3(\Delta\beta_{H,i}) + b_4(\sigma_{s,i}) + b_5(\Delta\sigma_{s,i}) + \varepsilon_{i,t}. \quad (7)$$

HSA-related return (HSA-R) and expected R&D intensity (ERDTA) are predicted to be negatively related. HSA-R_i measures firm i's stock market value reaction to surprise announcements associated with the HSA. We expect most firms' stock prices to react negatively, with the most R&D intensive firms most negatively affected.

But there are a number of alternative hypotheses. The relation could be positive. R&D-intensive firm's stock prices could increase if investors believe that the profit effects of lower prices would be offset by greater quantity demanded. The HSA proposed extended prescription

coverage, and the Clinton Administration argued that lower prices would make pharmaceuticals more affordable. R&D intensive firms could benefit most. But Coulson and Stuart (1995) show that the demand for pharmaceuticals is inelastic, making it unlikely that the decrease in profit per unit could be made up in larger volumes. Nevertheless, some firms could benefit if price constraints discourage rivals from developing competing drugs in the future, extending the profitable life of their drugs.

Another alternative is no relation. For example, high R&D intensive brand-name firms could be very negatively affected, but low R&D-intensive generic drug firms could be the most negatively affected. This is possible because generic firm's feedstock is brand-name drugs that eventually come off patent. Brand-name firms could cut back R&D, limiting new drug discovery, and decide to market their own generics[5]. HSA effects also could be negligible because the passage of the HSA was not assured.

HSA-R and β_H are expected to be negatively related because, as noted above, greater R&D leverage implies a larger β_H. This is also true for the relation between HSA-R and $\Delta\beta_H$. The value of high-leverage R&D projects will be more negatively affected. Alternatively, the relation between HSA-R and β_H could be positive because, according to the CAPM, beta is positively related to expected stock returns. But the relation between HSA-R and $\Delta\beta_H$ should still be negative because a surprise increase in beta should depress stock price.

HSA-R and σ_s (and $\Delta\sigma_s$) are expected to be positively related because large σ_s implies larger option value, all else equal. Therefore, the HSA-induced R&D value change will be proportionately less. Alternatively, the relation could be negative because option expected return is negatively related to σ_s (see Galai and Masulis, 1976).

[5] Indeed, brand-name drug firms have recently used strategies to squeeze profits from generic firms by licensing their drugs to selected generic firms just before patent expiration (see Hovey (2004)), or by producing generics themselves.

The weighting of a firm's liquid assets could help explain HSA-R in the following way. According to (4), (5), and (6), high W_L should cushion a firm's HSA-related risk and return effects because liquid asset values remain constant. This effect should already be captured by (7) because high W_L firms will have smaller $\beta_{H,i}$, $\Delta\beta_{H,i}$, $\sigma_{s,i}$, and $\Delta\sigma_{s,i}$, all else equal. If we interact W_L with $\beta_{H,i}$, $\Delta\beta_{H,i}$, $\sigma_{s,i}$, and $\Delta\sigma_{s,i}$, and include these interactions in (7), there should be no additional explanatory power.

But this implicitly assumes that firms respond to the HSA optimally. Jensen (1986) suggests that firm managers with freely available cash may not act in the firm's best interest, and Guedji and Scharfstein (2004) show that high-cash biotech firms often overspend on R&D. If the HSA causes a mere wealth transfer or actually improves drug profitability, then firms should continue investing cash in R&D projects. If the HSA makes some R&D projects unprofitable, however, firms should conserve cash and cut R&D. But if investors expect firms to waste cash on unprofitable R&D, then the W_L–interacted variables should help explain HSA-R. High W_L provides managers financial slack and should accentuate the negative (positive) effects of $\beta_{H,i}$, $\Delta\beta_{H,i}$ ($\sigma_{s,i}$ and $\Delta\sigma_{s,i}$) on HSA-R.

Finally, we also consider whether the brand-name drug firms who voluntarily constrain price increases suffer relatively large stock price declines[6]. HSA passage could have forced them to make their pledge more permanent than the market expected. In this case, HSA-R and a variable identifying price constrained firms should be negatively related. Alternatively, because the firms pledged to constrain their prices before the HSA-related events, the effect could be negligible.

The second empirical model defines the effects of the HSA on subsequent firm R&D decisions.

[6] In (1), the marketing subsidiary's value falls because lower price increases reduce the growth rate g.

$$URDTA_{i,t} = b_0 + b_1(HSA\text{-}R_i) + b_2(\Delta\beta_{H,i}) + b_3(\Delta\sigma_{s,i}) + \varepsilon_{i,t}. \quad (8)$$

Unexpected R&D (URDTA) and HSA-R are predicted to be positively related. The HSA is expected to decrease stock prices because firms' R&D investment is less valuable. Clearly, from (2), if the R&D call option value falls below the required R&D expense, then management should not incur the R&D expense and decline the option. Hence, managers are expected to reduce R&D investment below some normal or expected level, where the expected level is defined without regard for the effect of stock prices on R&D investment. This assumes that the more R&D-intensive firms are more likely to have at least some R&D projects with options values that fall below their R&D expenses.

An alternative hypothesis is no relation. Managers may not cut R&D spending when stock prices fall if all pharmaceutical R&D projects involve large rents that the HSA simply transfers from producers to consumers.

A more palatable alternative hypothesis is that firms with R&D projects in their earliest stages would exercise their option to delay or abandon R&D, while others with very late stage R&D projects could actually increase R&D, at least in the short-run. Late-stage drugs could be accelerated to market before the HSA takes effect. We do not have data on the vintage of firms' R&D projects, but this alternative hypothesis implies that the relation between R&D expenditure and stock price changes could be weak due to the mix of firm responses.

In addition to reacting to stock price changes, managers may also react to risk changes. URDTA and $\Delta\beta_H$ are predicted to be negatively related. An increase in β_H signifies that R&D has become more leveraged. In response, managers should reduce R&D spending, all else equal. Alternatively, some managers could "go for broke" and continue to fund R&D. This is particularly true for firms with R&D projects very near completion that could escape price controls.

The relation between URDTA and $\Delta\sigma_s$ is theoretically positive but is potentially ambiguous. The option value of R&D investment increases with $\Delta\sigma_s$. This should induce managers to increase R&D, all else equal. But risk-averse managers may react negatively to any increase in volatility, systematic or unsystematic. This implies a negative relation.

As in the first model, we also test whether the weighting of a firm's liquid assets helps explain URDTA. The idea is to see if managers' reactions to risk changes are influenced by W_L. W_L will be interacted with $\Delta\beta_{H,i}$ and $\Delta\sigma_{s,i}$, and included in (8). Because $\Delta\beta_{H,i}$ and $\Delta\sigma_{s,i}$ already include the cushioning effect of liquid assets, the interaction effects should be insignificant. But managers' R&D decisions could be influenced by their firms' liquidity position. High W_L could accentuate the negative (positive) effects of $\Delta\beta_{H,i}$ ($\Delta\sigma_{s,i}$) on URDTA.

4. The data, the sample, and a graphical illustration of HSA effects

4.1 The data and the sample

The study employs financial accounting data and stock market data for each sample firm around the period of 1992-1993, when the events associated with the HSA occurred. The accounting data, such as annual R&D expenditures, are obtained from Standard and Poor's Compustat database. The stock market data, such as daily firm stock returns, are obtained from the Center for Research in Security Prices (CRSP). This limits the potential sample because both Compustat and CRSP cover few foreign firms. Nevertheless, some of the largest foreign pharmaceutical firms with significant operations in the U.S. are covered in our sample.

The sample selection process is structured to be inclusive. Unlike earlier studies, we do not focus solely on large firms. The process starts with all firms on Compustat with a North American Industry Classification System (NAICS) code of either 325412 (Pharmaceutical Preparation Manufacturing) or 325414 (Biological Product Manufacturing). Included firms must

have data available for at least the years 1991-1995. This selection process results in 176 firms. Of these 176 firms, 113 also have stock returns on the CRSP database covering the period. Finally, of these 113, only two have less then eight years of accounting data on Compustat. We eliminate these firms because they do not have enough data to allow us to reliably estimate their expected R&D spending using the model discussed below. Of the remaining 111, only one has eight years, two have nine years, and all of the others have at least 10 years of data, including the 1991-1995 period.

The study revolves around the effects of the HSA on companies' R&D spending decisions. This requires a standardized measure of R&D spending that allows comparisons across time and across firms of different sizes. We considered the ratio of R&D spending to a firm's total assets (RDTA) and the ratio of R&D spending to a firm's total sales (RDS). We selected RDTA because it gives more reasonable figures for the firms in our sample. RDS gives extreme values for those firms with little revenue. We rejected excluding these firms because this would bias the sample toward more established, low R&D-intensive firms.

The Appendix lists the 111 firms in our sample sorted by RDTA from lowest to highest and separated into quartiles. R&D, assets, and sales figures are adjusted for consumer price inflation (All Urban Consumers-All Items, Base Period 1982-84=100). The figures for each firm are calculated as an average over 1989-1991, the three-year period prior to the HSA-related events. Therefore, the RDTA figure for each company characterizes its intensity of R&D spending before the price regulation debate started. The problem of extreme RDS ratios is clear, particularly in quartiles 3 and 4. The RDTA ratios are consistently more reasonable. The Appendix also shows that not all biotech firms are high R&D-intensive, although most are. All of the generic firms are in the lowest RDTA quartile, with the brand-name pharmaceutical firms mostly in quartiles 1 and 2.

There are surprisingly few generic firms. Of course, some of the firms that we have labeled "pharmaceutical" also produce some generics, but these are few and their primary profit

generators are brand-name pharmaceuticals. Clearly, investors are willing to fund many R&D-intensive firms but few generic firms. There are 64 biotech firms; more than ten times the number of generics.

To get a better feel for the data and the sample, consider Table 1. Note that the accounting variables such as R&D and Total Assets are measured for each firm with annual data averaged over 1989-1991, the three-year period prior to the HSA-related events. The returns-based variables are measured using daily stock returns. Beta is measured using the market model with the CRSP value-weighted index. Beta and return volatility for each firm are measured over the pre-event period covering April 24, 1990 to January 10, 1992. The pre-event period directly precedes the event period (January 13, 1992 to September 29, 1993), and is selected so that it has the same number of trading days as the event period. The event period consists of 434 trading days starting five trading days before the first HSA-related event (see Table 2), and ends five trading days after the last HSA-related event. Beta change (volatility change) is measured as the difference between the event period beta (volatility) and the pre-event period beta (volatility).

Because the large pharmaceutical firms mostly fall into quartile 2, that quartile has the largest average dollar amount of R&D spending and assets, followed by quartiles 1, 3, and 4. In deference to the wide variation in firm size, we present equal-weighted and size-weighted results in the figures below.

[Table 1 here]

In the model section, we discussed how R&D is equivalent to a leveraged investment. Hence, one would expect that the more R&D intensive the firm, the larger its beta. Indeed, the average betas increase with R&D intensity. Quartile 4 firms are about 50 percent more risky than quartile 1 firms. The difference in average betas between quartiles 1 and 2 is statistically significant (t-statistic = 2.08). Differences between quartile 1 and the others are more highly significant. Average betas for quartiles 2 and 3 also differ (t-statistic = 1.74), but the average betas for quartiles 3 and 4 are not significantly different at conventional levels.

A similar monotonic relation is observed for average return volatilities, however, quartiles 1 and 2 (and quartiles 3 and 4) have almost the same average volatilities. Not surprisingly, F-tests of the difference in average volatility between quartiles 1 and 2, and between quartiles 3 and 4, show no statistically significant differences. However, F-tests show that the average volatilities of the first two quartiles differ from the second two quartiles beyond the 1 percent significance level.

The average beta changes are not statistically different across quartiles, mostly because of the relatively large variation in beta changes within each quartile. This could indicate that there is large variation in firms' R&D sensitivity to the HSA within quartile. Nevertheless, it is surprising that the first quartile has the largest average increase in beta and the fourth quartile has the smallest. The small change in beta for the high-intensity R&D firms that make up quartile 4 can be rationalized from our discussion of equation (6). These firms have relatively large liquid asset weights, which we measure as the ratio of net working capital to total assets.

Average return volatility does not change much around the HSA, except for quartile 3. Furthermore, the differences between average quartile changes are statistically insignificant, except for the difference between quartile 1 and quartile 3. One surprise is that the average volatility falls for each quartile. A volatility decrease should decrease the R&D subsidiary's (option) value, and increase its beta. The volatility decrease is consistent with the possibility that the market expected price regulation to reduce future cash flow volatility, even while reducing average cash flows.

The quartiles also do not differ much with respect to capital expenditure intensity, measured by the ratio of capital expense to assets. The one exception is that the average capital expenditure intensity of quartile 2 is significantly larger than those of the other three quartiles. This can be explained by the fact that the second quartile contains many large pharmaceutical firms that must spend heavily on production and office facilities. The same pattern appears for advertising intensity, where large brand-name pharmaceutical firms must spend to promote their

products. Finally, financial leverage, measured by the ratio of debt to assets, shows that the firms in the first two quartiles are more leveraged than the firms in the second two quartiles. Leverage for quartile 1 and quartile 2 does not differ significantly. The same is true for quartiles 3 and 4. However, differences in average leverage between the first two quartiles and the second two quartiles are all significant at the 5 percent level. This reflects the fact that firms in quartiles 1 and 2 typically have significant cash flows that can be used to service debt. But none of the quartiles show high leverage.

4.2 A graphical illustration of the effects of the HSA on firm stock prices

To get a general idea of the magnitude of the possible effects of the HSA on our sample firms' stock prices, we present a graphical view of the cumulative total returns one would have earned on the stocks in our sample during the period when President Clinton's healthcare and pharmaceutical reform proposals became known to investors. We assume that investors partly impounded the value consequences of his views into stock prices.

Table 2 lists the major events that we believe were at least partial surprises to investors and that can be tied to President Clinton[7]. We wish to consider surprises because the returns around these events will more accurately represent HSA-related value effects. One can argue about which events to include. For example, we exclude events such as Clinton's acceptance of the Democratic presidential nomination because it was no surprise at convention-time. Furthermore, we do not select events based upon the actual returns that we observe around the event. For example, we include Clinton's election because we believe investors could have been surprised by it, even though our 111 stock portfolio increased in value around that event when one might have expected a decrease.

[Table 2 here]

[7] See Ellison and Mullin (2001) for more detail on these events.

The event period starts January 10, 1992, five trading days before Clinton first announced his healthcare reform plan. We include five days before the announcement because there is often leakage of news before a formal announcement, especially with regard to political proposals. The event period ends on September 29, 1993, five trading days after Clinton publicly announced the specific health plan to be sent to Congress.

Figure 1 shows the stock return performance of our sample firms during the event period. The returns are a value-weighted average of firm returns, and are equivalent to investing in a portfolio of the 111 stocks in proportion to their market values at the beginning of the event period. During the period, the portfolio value fell by about 32 percent while the overall value-weighted market portfolio increased by about 18 percent. After adjusting for risk using the market model[8], the value-weighted portfolio of 111 stocks fell 62 percent during the period.

[Figure 1 here]

But during this long period of time there could have been other negative events, unrelated to Clinton's HSA, which could account for some or most of the negative returns. To consider this possibility, Table 2 reports 11-day cumulative returns, covering five days before, and five days after, each of eleven major events. The sum of the returns over the 11 events is -38.56 percent, which exceeds the cumulative loss over the whole period. This means that the net effect of events on the other trading days during the full event period were positive. Nevertheless, our empirical tests do not rely on effects measured over the full event period or the 11 events. Indeed, our empirical tests will use only the last four events, all of which occur in 1993 when Clinton is

[8] The market model is

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

where R_{it} is firm i's daily stock return on day t, R_{mt} is the market return on day t represented by the CRSP value-weighted index, α_i and β_i are ordinary least squares coefficients for firm i, and ε_{it} in the error term for firm i at time t. The coefficients are estimated over the 255 trading days before the event period and used to calculate, A_{it}, the risk-adjusted return on a particular day t for firm i as,

$$A_{it} = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt} \ .$$

We calculate the compound sum of risk-adjusted daily returns during the event period for each firm, and weight that sum by each firm's total market value as a proportion of the total market value of all 111 firms. The risk-adjusted portfolio return is the sum of the 111 weighted returns.

president and has more influence on policy changes. These four events account for an 18.19 percent decline in pharmaceutical stock prices.

Figure 2 illustrates the return effects of the HSA for the 111 firms stratified by RDTA into quartiles. The first graph plots the cumulative returns earned by each quartile of firms with each firm's return weighted by its market value as a proportion of the total market value of the firms in its quartile at the beginning of the event period. Quartile 1 returns are plotted as the first thin line on the graph, followed by a thick line for quartile 2, then a thin line for quartile 3, and finally a thick line for quartile 4. The figure shows a consistent pattern of larger negative returns for higher R&D-intensive firms. By the end of the event period, the average stock in quartiles 1 through 4 fell by 23.57, 32.42, 45.04, and 59.73 percent, respectively. The time series pattern for each quartile is very similar, hence, outlier firms are not driving the results. Quartiles 1 and 2 have more similar effects, as do quartiles 3 and 4, particularly in 1992. This is consistent with the descriptive statistics in Table 1, which showed that these quartile pairs are comprised of firms with some similar characteristics.

[Figure 2 here]

To see whether value-weighting affects the graph, consider the second graph in Figure 2. Here, the returns of each firm are equal-weighted within each quartile. Therefore, results in this graph cannot be driven by a few large firms in a quartile. The results are qualitatively the same, although the return differences between the quartiles are not quite as large.

Figure 3 plots the returns for each quartile after adjusting each firm's return for its beta risk using the market model. The first graph shows risk-adjusted returns weighted by market values and the second graph shows them weighted equally. Compared to Figure 2, risk adjustment causes two changes. First, the decline in firm stock value is more precipitous. By the end of the event period, stocks in quartiles 1 through 4 stocks fall by 64.31, 58.49, 75.51, and 92.63 percent, respectively. The continuous, relatively smooth decline over the period illustrates

that the occasional moves up observed in Figure 2 are often driven by general stock market moves.

[Figure 3 here]

The second difference caused by risk-adjustment is that quartile 1 stocks now slightly under-perform quartile 2 stocks. This is surprising because the average beta of quartile 2 firms exceeds that of quartile 1 firms. The result is partly driven by the fact that the larger firms in quartile 1 have relatively large betas. The ten largest firms in quartile 1 have an average beta of 1.13 compared to the overall average of 0.98. The risk adjustments for these highly-weighted stocks pull down the average return for the quartile. Also recall that the average increase in beta for quartile 1 exceeded that of quartile 2. This could indicate differences in the types of R&D projects for the two quartiles, and consequently, different stock price reactions.

The second graph in Figure 3 plots risk-adjusted returns but uses equal-weighted returns. The results are similar to those in the first graph except that each quartile's returns end up lower. This shows that the smaller firms had relatively poor risk-adjusted returns, pulling down the equal-weighted average. The equal-weighted returns for the first two quartiles are about the same.

Finally, consider Figure 4. In the model section, we suggested that one way to help determine which firms had vulnerable R&D projects was to observe their beta changes and return volatility changes around the HSA. Figure 4 presents the value-weighted stock returns for the firms stratified into quartiles by beta change (first graph) and volatility change (second graph). The first graph shows that the firms with the smallest (quartile 1) and largest (quartile 4) beta changes experienced relatively large negative returns. The middle beta change quartiles (2 and 3) experienced returns similar to one another, and less negative than the returns of quartiles 1 and 4.

[Figure 4 here]

The second graph in Figure 4 shows that when firms are stratified by volatility change, the pattern of results is similar to those for beta change. This is not surprising because beta change and volatility change are positively related. But the results are not identical. One

difference is that volatility-change quartiles 1 and 4 have much greater negative returns than beta-change quartiles 1 and 4. Also, the difference in the performance of quartiles 2 and 3 compared to quartiles 1 and 4 is much larger. Furthermore, quartile 2 and 3 no longer produce similar returns, at least once Clinton takes office in 1993. Quartile 2 significantly out performs quartile 3 in 1993.

Results for quartiles stratified by beta and volatility level (available on request) have the monotonic relation illustrated in Figure 2. One difference is that the first three beta quartiles have returns relatively close together while quartile 4 has much more negative returns than the first three. For volatility level quartiles, the last three quartiles' returns are relatively close together and much more negative than the first quartile's return.

Taken together, these results suggest the relation between HSA-related returns and risk levels could be monotonic, but the relation between HSA-related returns and risk changes may not be. As shown below, accounting for firms' liquid asset intensities helps explain these effects.

5. Statistical tests

The graphs illustrate the magnitude of the effects that the healthcare reform debate and the HSA appeared to have on pharmaceutical firms' stock prices. The relatively large effects on the most R&D intensive firms are consistent with the HSA's proposed price restrictions on new drugs. This section presents some statistical tests of the relations discussed in section 3. Section 5.1 models a pharmaceutical firm's normal (expected) R&D spending behavior, excluding the effects of stock prices. Given an estimate of expected R&D spending, we can then calculate unexpected R&D spending. Section 5.2 tests the significance of the relations defined in the empirical models (7) and (8). The effects of self-imposed price constraints and financial leverage on these relations also are considered. Section 5.3 discusses how the HSA might have indirectly affected firms' capital expenditure and advertising because these items could be complements or

substitutes for R&D. This leads to a discussion of the effect of the HSA on firms' stock prices after it was defeated.

5.1 A model of expected and unexpected R&D intensity

To decide whether the HSA had a significant effect on firm-level pharmaceutical R&D spending behavior, we need measures of expected R&D spending, unexpected R&D spending, and the HSA effects on firms' stock prices. As previously discussed, we use R&D-to-Assets (RDTA) to measure R&D spending intensity. This standardized measure is better behaved for our sample than R&D-to-sales, and is more comparable across time and across firms of different sizes, than raw dollars of R&D spending. Eberhart, Maxwell and Siddique (2004) also use RDTA to identify significant R&D changes. Henceforth, we use RDTA and "R&D spending" interchangeably. The HSA may not reduce the total dollar amount of R&D spending, but firms may increase spending at a slower rate relative to asset growth. RDTA should capture such behavioral changes.

We need measures of expected and unexpected RDTA to determine if firms changed their spending behaviors in reaction to the HSA. Because the HSA did not become law, it did not directly reduce firms' product prices, sales, cash flows, etc. Therefore, we can use financial accounting variables to estimate a firm's RDTA in a particular year. Earlier studies such as Grabowski (1968), Lichtenberg (2004), and Himmelberg (1994) used sales, cash flows, or assets. Large firms may rely on sales and cash flows, but Hall (2002) shows that small firms rely on investor financing. As they raise capital in a particular year, their current assets and working capital, and as a result their R&D, increase in that year. Mikkelson and Partch (2003) document the positive contemporaneous relation between cash holdings and R&D expenditures. Therefore, we use the following model that combines these major drivers of R&D spending.

$$RDTA_{i,t} = a_0 + a_{i,1}(Sales_{i,t}) + a_{i,2}(Assets_{i,t}) + a_{i,3}(Cash\ Flow_{i,t}) + a_{i,4}(Current\ Assets_{i,t}) + a_{i,5}(Working\ Capital_{i,t}) + \mu_{i,t}. \quad (9)$$

Regression model (9) relates firm i's RDTA to its sales, assets, cash flow, current assets, and working capital, all measured at time t. The fitted values from the regression measure a firm's expected RDTA. Unexpected RDTA for each firm i in year t, is measured as the error term ($\mu_{i,t}$) from (9). The purpose of the model is to get an accurate prediction of R&D based on accounting variables but not stock price changes[9]. If firms react to stock price changes by changing RDTA, then this change in behavior should be captured in $\mu_{i,t}$.

We want to capture each firm's R&D spending behavior around the HSA, therefore, we estimate the regression separately for each firm over the years for which it has annual Compustat data during 1980-2000. Most firms have at least ten years of data during this period (one firm has eight and two have nine years). Only 22 firms have data before 1980 and 25 firms have no data after 2000.

Table 3 illustrates how these variables were changing for the average firm in our sample around the time of the HSA. The variables are in real terms, where dollar figures have been adjusted for consumer price inflation (All Urban Consumers-All Items, Base Period 1982-84=100). The means of the variables in each year between 1989 and 1996 are presented for the full sample and for RDTA quartiles.

[Table 3 here]

Clearly, the industry experienced strong growth during the period. For the average firm between 1989 and 1996, R&D went from \$64 to \$108 million, assets went from \$729 to \$1166 million, sales went from \$712 to \$959 million, cash flow went from \$120 to \$184 million, and current assets went from \$381 to 487 million. But working capital actually decreased from \$165

[9] This model provides relatively good explanatory power. The average R-Squared from this regression for the 111 firms in our sample is 0.66.

to $138 million. Somewhat surprising is the negative return on assets in each year. This is true for each quartile, with very poor returns for quartiles 3 and 4, which have many small, low-revenue firms. Average cash flow is negative in each year for quartiles 3 and 4. But these quartiles still have much higher growth in the other variables than quartiles 1 and 2.

Clearly, firms in quartiles 3 and 4 rely heavily on external financing sources to fund R&D. This can be seen in the large jump in current assets and working capital from 1990 to 1991 for both quartiles. Lerner, Shane, and Tsai (2003) document a large spike in initial public offerings and follow-on offerings for biotech firms during this period. They suggest that the subsequent sharp drop-off in external financing was due at least partly to the HSA.

Consider unexpected RDTA figures for the full sample and the quartiles. If firms reduced R&D spending intensity in response to HSA-related stock prices declines, we should expect to see negative unexpected RDTA in 1993, or perhaps 1994 or even 1995. For the full sample, average unexpected RDTA is negative in 1993 but it is positive in 1994 and 1995. But the averages vary by quartile. Quartiles 1 and 4 have negative average unexpected RDTA in 1994 and 1995, but quartiles 2 and 3 have negative average unexpected RDTA in 1993. This illustrates how the effect could vary across different firms. Furthermore, some firms could be positively affected by the HSA and increase their RDTA in response. Indeed, 21 of the 111 firms had positive HSA-related returns.

The final component required to test our propositions is a measure of HSA-related stock returns. Our approach uses a conservative measure of the HSA effects on stock prices. We only use the four major events that occurred after Clinton became president in 1993 (see Table 2). The first event is the appointment of Hillary Clinton to head the group charged with writing the HSA. She was known to be predisposed to price constraints. The second event is a speech by Clinton in which he directly states that pharmaceutical prices were too high. The third event is the New York Times story reporting specific regulations from a leaked preliminary copy of the HSA. The fourth event is the formal release of the plan. The combined returns for each firm around these

four events measures its HSA-related stock return. The average firm HSA-related return is -18.19 percent. The combined CRSP value weighted index return around the four events is 2.4 percent.

This measure probably understates the true effect of the HSA. But our tests do not require a measure of the total effect. We simply need a proxy variable that accurately measures the effects that the HSA had on each firm relative to the other sample firms. As it turns out, our results are robust to whether we measure the HSA return using all the events or the whole event period. Nevertheless, we are more confident that the measure that we use does not contain potentially confounding effects.

5.2 Empirical model test results

Table 4 reports the results for the regression tests of empirical model (7) for the relations between HSA-related return (HSA-R) and expected R&D intensity (ERDTA), beta ($\beta_{H,i}$), beta change ($\Delta\beta_{H,i}$), volatility ($\sigma_{s,i}$,), and volatility change ($\Delta\sigma_{s,i}$). The relations between HSA-R and unexpected R&D intensity (URDTA), and perhaps, ERDTA, could involve lags. Because the HSA-R is measured in 1993, results are presented for 1993, 1994, and 1995. Results are stronger when the data are pooled, but because only ERDTA and URDTA change by year, pooling likely overstates the strength of the relations.

The first three regressions in Table 4 show that HSA-R and ERDTA are negatively related, although only the 1994 regression estimate is statistically significant. This supports Figure 2 which showed that the more R&D-intensive firms experienced larger negative HSA-related returns. Investors apparently used R&D intensity as one measure of how much the sample firms' future prospects would be affected by the HSA, above and beyond the effects of risk and risk changes.

[Table 4 here]

Both $\beta_{H,i}$ and $\Delta\beta_{H,i}$ are negatively related to HSA-R in each regression. It is no surprise that increases in betas could explain the negative HSA-related returns, but the negative relation

between beta and HSA-R only makes sense from an options perspective, where investors used beta as a measure of R&D leverage, and expected high R&D-leveraged firms to perform relatively poorly. Market returns during the event period were positive, hence, according to the CAPM, sample firms with larger betas should have experienced larger returns on average.

HSA-R and $\sigma_{s,i}$, are positively related, which also supports an options interpretation. Greater volatility ordinarily has a non-positive effect on stock value in most asset pricing models, except for options models. The relation between HSA-R and $\Delta\sigma_{s,i}$ is statistically insignificant.

The relations between HSA-R and the risk variables could be misleading if the level of liquid asset intensity differs significantly across firms. To consider this possibility, we interact the risk variables with a liquid asset intensity variable (L) and add these new variables to the regression. L is measured as the ratio of firm working capital to total assets. We report the regression for 1994, the other years show similar effects.

The fourth regression in Table 4 shows that firm liquidity had a significant effect on how investors impounded the expected effects of the HSA into firm stock prices. The relations between HSA-R and $\beta_{H,i}$ and $\Delta\beta_{H,i}$ are now insignificant. Similarly, the relations between HSA-R and $\sigma_{s,i}$ and $\Delta\sigma_{s,i}$ are also insignificant. But all of the estimates on the interacted variables are significant. The negative estimates on ($\beta_{H,i}$ x L) and ($\Delta\beta_{H,i}$ x L) imply that investors believed that high-liquidity-high-beta (or beta change) firms would be most negatively affected by the HSA. Conversely, they believed high-liquidity-high-volatility (or volatility change) firms would be least negatively affected or actually positively affected. These results suggest that investors valued (discounted) a tight liquidity constraint for managers of firms with high-beta (high volatility) R&D projects.

Finally, the last regression includes a variable to test whether firms that pledged to keep price increases low experienced relatively low returns. Twenty-one established firms pledged by mid-1993 to keep their drug price increases below the general consumer price inflation. Of the 21

firms listed in Ellison and Mullin (2001), ten are part of our sample[10]. The price constraint dummy (PCD_i) variable equals 1 if firm *i* pledged to keep its price increases below the inflation rate, and equals zero otherwise. The point estimate on PCD is negative but it is not statistically significant.

Table 5 reports the regression tests of empirical model (8) for the relations between URDTA and HSA-R, $\Delta\beta_{H,i}$, and $\Delta\sigma_{s,i}$. Results for the first three regressions show that URDTA and HSA-R are positively related, although only the 1994 effect is statistically significant. This implies that the largely negative HSA-R induced firms to cut their R&D intensity. Because HSA-R is measured from events that occur as late as September 1993, it makes sense that the most significant effects occur in the following year's R&D spending. This is also consistent with Table 4 results that showed that the 1994 data provided the strongest relation.

URDTA and $\Delta\beta_{H,i}$ also are positively related, with both the 1993 and 1994 estimates statistically significant. According to the options model, the average increase in β_H for the sample firms implies increased R&D leverage. And Table 4 shows that the larger the $\Delta\beta_{H,i}$, the greater the decline in firm stock price. The optimal response by managers should be to reduce R&D spending. But the positive estimate implies that high $\Delta\beta_{H,i}$ firms actually increased their R&D spending (or decreased it less than expected).

The relation between URDTA and $\Delta\sigma_{s,i}$ is not consistent across years, although the only statistically significant estimate is positive. The average decrease in $\sigma_{s,i}$ for the sample firms implies smaller R&D option value. In response, managers should reduce R&D spending, which is consistent with the positive estimate.

The effects of firm liquidity on managers' R&D spending decisions can help explain these results. The fourth regression in Table 5 shows that firm liquidity had a significant effect on

[10] Our sample includes Abbott Labs, Bristol-Meyers Squibb, Eli Lilly, Glaxo, Johnson & Johnson, Merck, Pfizer, SmithKline Beecham, Warner-Lamber and Wyeth-Ayerst (American Home Products). The other firms are Ciba-Geigy, Dupont-Merck, G.D. Searle, Genentech, Hoechst-Roussel, Hoffmann-La Roche, Knoll, Marion Merrell Dow, Syntex, Upjon, and Zeneca. These 11 firms do not have the necessary data.

how managers responded to HSA–related stock price changes. Again, L is interacted with the risk change variables and these new variables are added to the regression. The relations between URDTA and $\Delta\beta_{H,i}$ and $\Delta\sigma_{s,i}$ are now insignificant, although the point estimates are negative. The negative estimates are consistent with a negative response by managers to increased risk.

The positive estimate on ($\Delta\beta_{H,i}$ x L) is significant. This implies that high-liquidity-high-beta-change (low-liquidity-low-beta-change) firms tended to increase (decrease) R&D spending in response to the HSA. These results mean that liquidity constrained low-beta-change firms were more likely to respond optimally to the negative implications of the HSA. The effect is not purely liquidity driven because if L is included separately in the regression, it is not statistically significant, although the point estimate is positive. The positive estimate on ($\Delta\sigma_{s,i}$ x L) is insignificant.

The last regression in Table 5 includes the price constraint dummy (PCD) variable to test whether firms that pledged to constrain price increases reduced R&D spending relative to the other firms in the sample. The PCD estimate is positive but insignificant. But this is because pricing constraints likely reduced these firms' sales, cash flows, etc., which are used in (9) to estimate ERDTA. Because URDTA is stripped of these variables' influences, it is not surprising that URDTA and PCD are unrelated. When we re-estimate the last regression in Table 5 using ERDTA as the independent variable, the estimate on PCD is negative and significant in each regression[11]. Therefore, self-imposed price constraints reduced firms' R&D spending. The 1994 regression has the largest negative estimate on PCD. This is consistent with Ellison and Wolfram (2001) who show that the firms' self-imposed price restrictions were most evident in firms' 1994 drug prices.

We also considered whether financial leverage had any impact on the results. High-leverage firms' stock prices could have dropped more in response to the HSA, and managers'

[11] These results are available upon request.

R&D spending flexibility could have been constrained by debt. We added a total-debt-to-assets variable to each regression in Tables 4 and 5 and re-estimated the regression (not shown). None of the estimates on this leverage variable were significant. This is not surprising given the low debt levels of the sample (see Table 1).

Finally, we estimate the magnitude of the effect that the HSA had on firm R&D. From Table 2, the average firm experienced a -18.19 percent HSA-related return. Given the 1994 estimate of 0.14 for the relation between URDTA and HSA-R, the average firm decreased their RDTA by about 0.025 below its expected level. With the average RDTA of about 0.30 in 1994 (see Table 3), this is about an 8.3 percent decline. This is equivalent to about $796 million ($1.61 billion) in 1983 (2004) dollars. This probably underestimates the effect because it assumes that only 1994 R&D was affected and excludes the effects of self-imposed price constraints.

5.3 The HSA effects on capital expenditures and advertising

The HSA apparently affected firms' R&D spending decisions. Spending on related items could also be affected by the HSA if the items are complements or substitutes for R&D. Two relevant items are capital expenditure and advertising. We reran the regressions in Table 5 above using unexpected capital expenditure intensity (UCAPEXTA) and unexpected advertising intensity (UADVTA) in place of URDTA. UCAPEXTA and UADVTA were estimated using the same approach as URDTA. Given the limited statistical significance or sample sizes for these regressions, we only summarize the results here (available upon request).

All of the sample firms report capital expenditure in each year so sample size is 111 firms. We find that, like URDTA, UCAPEXTA is positively related to HSA-related return in all of the regressions, but none of the estimates is statistically significant at the ten percent level. This makes sense if R&D and CAPEX are weak complements. With lower R&D spending, one would expect less need for plant and equipment, but spending on these items is probably less flexible.

Unlike CAPEX and R&D, firms are not required to report advertising as a separate item. Consequently, only 51 sample firms report advertising expense. Nevertheless, with the available sample we find that UADVTA is negatively related to HSA-related returns. Although statistically insignificant unless data for all three years are pooled, the negative relation between UADVTA and HSA-R is intriguing. The results suggest that R&D and advertising are weak substitutes. This makes sense in the context of our model. That is, in the face of prospective price regulation for future drugs, firms reduce R&D and increase advertising expenditure to support sales of current products.

Finally, consider Figure 5 which plots the cumulative value-weighted returns of the stocks in each RDTA quartile over a post-HSA period. Like the HSA event period, it includes 434 trading days, but starts September 30, 1993, the day after the HSA event period ends. The figure illustrates an interesting dynamic. As Ellison and Mullin (2001) note, the HSA lost political momentum immediately after it was presented to Congress on October 3, 1993 by Hillary Clinton. The figure shows that each quartile of stocks rallied as the HSA lost its support, outperforming the market through the beginning of February 1994. But by the time Senator Bob Dole pronounced the HSA "dead" on March 2, 1994, all of the quartiles had lost their gains.

[Figure 5 here]

By the time Congress officially shelved the HSA on July 21, 1994, a clear dichotomy had emerged in the industry. The low R&D intensity quartiles 1 and 2 had fully recovered while quartiles 3 and 4 had plunged. By mid-1995, the divergence between the quartiles was considerable. In particular, quartile 2, that contains most of the brand-name firms, was outperforming the market.

A full explanation of this dichotomy is beyond the scope of this paper. But we conjecture that the HSA did indeed have long-term effects on the pharmaceutical industry even though it never passed Congress. Giaccotto, Santerre, and Vernon (2005) illustrate how the real price of pharmaceuticals increased steadily from 1980 through 1992, but remained constant from 1993

through 1997. Under these conditions, the value of brand-name firms could have increased because they increased advertising, which increased the value of their marketed drugs. But the values of firms in quartiles 3 and 4 rely solely on their R&D project values. If the HSA marked the beginning of implicit pricing limitations, brand names could have become more valuable while R&D became less valuable.

6. Conclusion

Although some theoretical and simulation-based research has shown that pharmaceutical price regulation would reduce industry-level R&D spending, there is little empirical work documenting a link between price regulation and firm-level R&D spending. This paper uses the Clinton Administration's Health Security Act (HSA) as a natural experiment to show that pharmaceutical firms, threatened by price regulation, reduced their R&D spending by about $1.6 billion in current dollar terms.

We show that the threatened regulation generated R&D effects through firm stock prices and that the effects are consistent with the real option characteristics of R&D. After predicting each firm's R&D spending based upon accounting variables such as sales and current assets, we show that unexpected R&D spending is positively related to their HSA-related stock returns (which were excluded from the R&D prediction model). Because most firms experienced significant negative HSA-related returns, many responded by reducing R&D spending from expected levels. Given that the HSA was presented to Congress in late 1993, it is not surprising that the most significant negative effect on R&D appears in 1994.

Events leading up to the formal presentation of the HSA to Congress could be traced as far back as the Democratic primaries in early 1992. We show graphically that pharmaceutical company stocks sustained significant price declines from then until late 1993. The average firm experienced a -38 percent return during a period when the general stock market earned about 18

percent. But relatively R&D intensive firms suffered larger losses on average. Even after the HSA was defeated in Congress, R&D intensive firms continued to suffered larger stock price losses while less R&D intensive firms' enjoyed stock price gains.

The average firm's R&D spending declined by only about eight percent. This is partly because many R&D intensive firms happen to have raised much of their capital just before the HSA-related events began. Indeed, results show that high-liquidity firms with R&D projects that are most sensitive to the HSA suffer relatively large price declines. We conjecture that had the HSA become law, the long-term effect on R&D spending would have been much greater for the most R&D intensive firms because they would have been unable to continue to raise financing.

Finally, we find that there was no statistically significant change in firms' capital expenditures. Nevertheless, the sign of the relation between unexpected capital expenditures and HSA-related return is the same as the sign of the relation between their unexpected R&D expenditures and HSA-related return. Based upon limited data, the relation between unexpected advertising spending and HSA-related return is negative although usually statistically insignificant. This suggests that some firms may have responded to the HSA by reallocating resources from R&D to advertising.

References

Abbott, Thomas A., 1995, Price regulation in the pharmaceutical industry: Prescription or placebo? Journal of Health Economics 14, 551- 565.

Chan, Louis K. C., Josef Lakonishok, and Theodore Sougiannis, 2001, The stock market valuation of research and development spending, Journal of Finance 56, 2431-2456.

Coulson, E. N. and Stuart, B. C., 1995, Insurance choice and the demand for prescription drugs, Southern Economic Journal 61, 1146-1157.

Durnev, Art, Randall Morck, and Bernard Yeung, 2004, Value-enhancing capital budgeting and firm-specific stock return variation, Journal of Finance 59, 65-106.

Eberhart, Allan C., William F. Maxwell, and Akhtar Siddique, 2004, An examination of long-term stock returns and operating performance following R&D increases, Journal of Finance 59, 623-650.

Ellison, Sara F. and Catherine Wolfram, 2001, Pharmaceutical prices and political activity, Massachusetts Institute of Technology Working Paper.

Ellison, Sara Fisher, and Wallace P. Mullin, 2001, Gradual incorporation of information: Pharmaceutical stocks and the evolution of President Clinton's health care reform, Journal of Law and Economics 44, 89-130.

Finkelstein, A., 2004, Static and dynamic effects of health policy: evidence from the vaccine industry, Quarterly Journal of Economics 119, 527-564.

Galai, D., and R.W. Masulis, 1976, The option pricing model and the risk factor of stock, Journal of Financial Economics 3, 53-82.

Giaccotto, Carmelo, Rexford Santerre, and John Vernon, 2005, Pricing and R&D investment behavior in the pharmaceutical industry, Journal of Law and Economics, forthcoming.

Guedj, Ilan and David Scharfstein, 2004, Organizational scope and investment: Evidence from drug development strategies and performance of biopharmaceutical firms, MIT working paper.

Grabowski, Henry, 1969, The determinants of research and development: A study of chemical, drug, and petroleum industries, Journal of Political Economy 76, 292-306.

Hall, Bronwyn, 2002, The financing of research and development, Oxford Review of Economic Policy 18, 35-51.

Himmelberg, Charles P., and Bruce C. Petersen, 1994, R&D and internal finance: A panel study of small firms in high-tech industries, Review of Economics and Statistics 76, 38-51.

Hovey, Hollister, 2004, Big pharma courts rivals of generic drugs, Wall Street Journal, August 11.

Jensen, Michael C., 1986, Agency costs of free cash flow, corporate finance, and takeovers, American Economic Review 76, 323-330.

Lerner, Josh, Hilary Shane, and Alexander Tsai, 2003, Do equity financing cycles matter? evidence from biotechnology alliances, Journal of Financial Economics 67, 411-446.

Lichtenberg, Frank R., 2004, Public policy and innovation in the U.S. pharmaceutical industry, in Public policy and the Economics of Entrepreneurship, eds. Douglas Holtz-Eakin and Harvey S. Rosen, MIT Press, Boston.

Mikkelson, Wayne H. and M. Megan Partch, 2003, Do persistent large cash reserves hinder performance?, Journal of Financial and Quantitative Analysis 38, 275-294.

Sager, Alan, and Deborah Socolar, 2004, Do drug makers lose money on Canadian imports?, Boston University working paper.

Vernon, John, 2005, Examining the link between price regulation and pharmaceutical R&D investment, Health Economics 14, 1-16.

Vernon, John, 2003, Simulating the impact of price regulation on R&D innovation, Pharmaceutical Development and Regulation 1, 55-65.

Appendix. Sample of 111 Pharmaceutical and Biotech Companies Sorted by R&D-to-Assets With Descriptive Variables Measured as Averages over 1989-1991.

The sample includes all companies in the NAICS categories 325412 (Pharmaceutical Preparation Manufacturing) and 325414 (Biological Product Manufacturing) that have Compustat financial data and CRSP stock return data covering at least 1991-1995. Company type is defined as either brand-name pharmaceutical (Pharmaceutical), generic pharmaceutical (Generic), or biotechnology (Biotech). Dollar figures are adjusted for consumer price inflation (All Urban Consumers-All Items, Base Period 1982-84=100).

Company Name	Company Type	R&D-to-Assets	R&D-to-Sales	R&D (millions)	Assets (millions)	Sales (millions)
Quartile 1						
Akorn Inc	Pharmaceutical	0.00027	0.0003	0.003	11.59	9.68
Jones Medical Industries Inc	Pharmaceutical	0.00127	0.0021	0.031	18.84	13.30
Quest Biotechnology Inc	Biotech	0.00551	0.0199	0.012	1.97	0.37
Natures Sunshine Products Inc	Pharmaceutical	0.01450	0.0055	0.251	17.31	46.03
Deprenyl Research Limited	Pharmaceutical	0.01725	0.0853	0.319	17.77	5.68
Chattem Inc	Pharmaceutical	0.01911	0.0123	0.839	43.81	67.78
Alza Corpa	Pharmaceutical	0.02380	0.0997	7.751	347.05	79.73
Bausch & Lomb Inc	Pharmaceutical	0.02842	0.0337	34.544	1216.44	1025.12
A L Labs Inca	Pharmaceutical	0.02992	0.0353	7.338	243.75	208.02
Theragenics Corp	Biotech	0.03238	0.1175	0.075	2.28	1.02
North American Vaccine Inc	Biotech	0.03380	0.7256	0.658	20.58	1.64
Balchem Corp	Pharmaceutical	0.03482	0.0201	0.167	4.76	8.25
Halsey Drug Inc	Generic	0.03490	0.0253	0.521	15.45	21.26
Forest Labs Inc	Biotech	0.03859	0.0686	9.625	248.60	139.06
Mylan Labs Inc	Generic	0.03868	0.0642	5.050	132.69	79.37
Atrix Laboratories Inc	Pharmaceutical	0.03903	0.1269	0.182	4.46	1.86
United Guardian Inc	Pharmaceutical	0.04123	0.0480	0.167	4.04	3.51
Teva Pharmaceutical Inds Ltd	Generic	0.04355	0.0467	10.320	237.24	220.82
Pharmaceutical Resources Inc	Generic	0.04648	0.0582	2.864	56.64	47.22
Ivax Corp	Generic	0.04860	0.0607	5.649	157.21	95.39
I G I Inc	Pharmaceutical	0.05972	0.0606	0.914	15.45	15.07

Medicis Pharmaceutical Corpa	Pharmaceutical	0.05981	18.8538	0.324	6.56	1.19
Elan Corp Plc	Biotech	0.06312	0.1293	6.985	107.99	53.13
American Home Products Corp	Pharmaceutical	0.06627	0.0555	285.742	4315.99	5151.94
Barr Laboratories Inc	Generic	0.06682	0.0622	3.625	54.77	58.17
Monsanto Co	Pharmaceutical	0.06791	0.0692	459.362	6765.58	6638.42
Pfizer Inc	Pharmaceutical	0.07102	0.1008	480.173	6745.34	4747.87
T Cell Sciences Inc	Biotech	0.07378	0.1230	0.926	13.87	7.55
Quartile 2						
Clinical Technologies Assoc Inc	Pharmaceutical	0.07605	0.2709	0.226	3.44	0.94
Taro Vit Chemical Industries Ltd	Pharmaceutical	0.07651	0.0577	0.665	8.44	11.21
Moleculon Inc	Pharmaceutical	0.07736	0.2935	1.965	25.32	20.09
Immunex Corp	Biotech	0.07925	0.3307	9.054	114.25	26.44
Allergan Inc	Pharmaceutical	0.08172	0.0875	55.311	680.68	632.60
I C O S Corp	Pharmaceutical	0.08565	25.3941	3.325	33.86	0.30
Rhone Poulenc Rorer Inc	Pharmaceutical	0.08724	0.1127	225.880	2473.79	1962.79
Novo Nordisk A S	Pharmaceutical	0.08956	0.1371	145.368	1620.37	1056.17
Johnson & Johnson	Pharmaceutical	0.09058	0.0756	631.203	6963.62	8338.77
Glaxo Holdings Plc	Pharmaceutical	0.09318	0.1351	516.322	5533.69	3797.18
Life Technologies Inc	Biotech	0.09362	0.0808	9.191	99.73	114.10
Schering Plough Corp	Pharmaceutical	0.09633	0.1118	282.233	2930.24	2521.85
Bristol Myers Squibb Co	Pharmaceutical	0.09797	0.0868	664.295	6778.00	7648.47
Lilly Eli & Co	Pharmaceutical	0.09810	0.1381	517.528	5302.03	3760.22
Polydex Pharmaceuticals Ltd	Pharmaceutical	0.10308	0.1772	0.291	2.77	1.91
Smithkline Beecham Plc	Pharmaceutical	0.10348	0.0848	547.775	5295.22	6460.37
Abbott Labs	Pharmaceutical	0.10396	0.0941	432.538	4156.94	4592.56
Merck & Co Inc	Pharmaceutical	0.10714	0.1136	646.280	6049.07	5690.16
Columbia Laboratories Inc	Pharmaceutical	0.11276	0.1623	1.109	10.02	7.10
Warner Lambert Co	Pharmaceutical	0.11392	0.0794	276.876	2425.32	3479.60
Amgen Inc	Biotech	0.13146	0.1862	53.964	416.81	308.85
Cephalon Inc	Biotech	0.13608	9.6600	3.388	26.37	1.85
I D E X X Laboratories Inc	Pharmaceutical	0.14342	0.1340	2.689	20.75	20.13

U S Bioscience Inc	Biotech	0.15256	100.118	4.414	37.57	0.88
M G I Pharma Inc	Pharmaceutical	0.15619	7.285	4.570	29.54	2.47
Centocor Inc	Biotech	0.15762	0.742	33.400	228.77	47.67
Neurogen Corp	Pharmaceutical	0.16884	167.146	1.671	10.33	0.01
Regeneron Pharmaceuticals Inc	Biotech	0.17963	1.694	6.964	50.72	4.07
Quartile 3						
Ribi Immunochem Resh Inc	Biotech	0.18167	2.368	1.523	8.63	0.64
Biogen Inc	Biotech	0.18933	0.766	25.899	138.33	34.67
Immune Response Corp	Biotech	0.19340	1.252	3.718	37.16	2.95
Enzon Inc	Biotech	0.19442	2.335	4.318	23.78	1.90
Immulogic Pharmaceutical Corp	Biotech	0.19489	1.899	4.440	24.88	2.35
Pharmatec Inc	Pharmaceutical	0.20725	0.354	0.232	1.17	0.74
Royce Laboratories Inc	Biotech	0.21019	0.209	0.228	1.45	1.18
Chiron Corp	Biotech	0.21614	1.138	43.658	314.36	38.82
Celtrix Pharmaceuticals Inc	Biotech	0.21703	13.835	5.396	28.68	0.42
Techne Corp	Biotech	0.22203	0.110	1.302	5.87	11.81
Medco Research Inc	Pharmaceutical	0.22792	21.336	0.391	1.81	0.90
Advanced Tissue Sciences Inca	Biotech	0.22844	30.983	2.047	9.73	0.17
Xoma Corp	Biotech	0.23996	1.871	21.040	90.17	11.93
Immucell Corp	Biotech	0.24184	0.312	0.532	2.41	1.73
Interneuron Pharmaceuticals Inc	Biotech	0.24860	18.555	1.414	4.66	0.05
Cel Sci Corp	Biotech	0.27146	11.654	0.116	0.63	0.01
Sepracor Inc	Biotech	0.27595	0.986	6.785	32.81	7.27
Celgene Corp	Biotech	0.29924	8.253	4.594	17.83	0.67
Repligen Corp	Biotech	0.30153	1.364	8.971	30.48	6.81
I M R E Corp	Biotech	0.30689	0.370	0.587	3.66	1.59
Procyte Corp	Biotech	0.30985	11.015	2.309	8.28	0.66
Carrington Laboratories Inc	Biotech	0.31620	0.269	2.247	7.12	8.71
Belmac Corp	Biotech	0.31722	43.056	0.492	1.66	0.01
Alkermes Inc	Biotech	0.31878	17.764	3.462	21.97	0.33
Cygnus Therapeutic Systems	Biotech	0.32492	1.042	4.031	12.39	3.51

Quadra Logic Technologies Inc	Biotech	0.33672	242.253	7.254	22.76	0.22
D D I Pharmaceuticals	Biotech	0.35194	0.426	1.248	3.55	3.17
Quartile 4						
Cytogen Corp	Biotech	0.35428	4.469	12.644	36.62	3.67
Isis Pharmaceuticals Inc	Biotech	0.35651	1.063	2.335	28.25	2.94
Unimed Inc	Biotech	0.35819	0.506	1.736	4.92	3.57
Somatix Therapy Corp	Biotech	0.36300	1.647	4.828	13.83	3.18
Vertex Pharmaceuticals Inc	Biotech	0.36777	2.515	4.834	24.08	1.94
Genelabs Technologies Inc	Biotech	0.37524	1.945	7.299	19.27	4.85
Cor Therapeutics Inc	Biotech	0.37652	5.834	3.866	24.55	1.05
Medimmune Inc	Biotech	0.37870	1.015	4.59	26.44	6.26
Somatogen Inc	Biotech	0.37919	12.915	3.607	10.08	0.67
Interferon Sciences Inc	Biotech	0.40603	8.879	3.305	10.81	0.82
Immunogen Inc	Biotech	0.43367	199.635	5.788	16.84	0.59
Liposome Technology Inc	Biotech	0.44257	11.866	5.371	16.52	0.64
Cortex Pharmaceuticals Inc	Biotech	0.49866	75.746	1.032	2.11	0.01
Liposome Company Inc	Biotech	0.50112	2.311	6.483	18.89	3.11
Roberts Pharmaceutical Corp	Biotech	0.50463	1.193	2.547	14.55	4.98
Agouron Pharmaceuticals Inc	Biotech	0.51026	3.243	5.867	11.90	1.90
Aphton Corp	Biotech	0.51749	81.370	0.995	3.064	0.03
Noven Pharmaceuticals Inc	Pharmaceutical	0.51754	13.158	1.324	2.55	0.10
Gensia Pharmaceuticals Inc	Biotech	0.54223	592.961	11.559	45.78	2.09
Applied Microbiology Inc	Biotech	0.62631	1.239	0.702	1.21	0.57
Organogenesis Inc	Biotech	0.69109	1.798	4.470	12.83	2.50
Lidak Pharmaceuticalsa	Biotech	0.73479	4.858	0.675	1.13	0.17
Medarex Inc	Biotech	0.74791	0.793	0.837	4.55	1.04
Biomatrix Inc	Biotech	0.77681	1.070	2.060	11.22	1.92
Greenwich Pharmaceuticals Inc	Pharmaceutical	0.88906	2.738	8.300	10.12	3.16
Cytrx Corp	Biotech	0.92669	1.702	1.005	6.43	1.55
Chantal Pharmaceutical Corp	Biotech	1.18779	4.638	2.337	2.11	1.11
Cambridge Neuroscience Inc	Biotech	1.78620	6.279	4.879	15.04	0.77

Table 1. Descriptive Statistics for Study Variables for the Full Sample and By R&D-to-Assets Quartiles.

Each firm observation for R&D, R&D-to-Assets, Total Assets, Capital Expense-to-Assets, Advertising-to-Assets, and Debt-to-Assets is measured as an average over 1989-1991. Dollar figures are adjusted for consumer price inflation (All Urban Consumers-All Items, Base Period 1982-84=100). Beta and return volatility for each firm is measured over the pre-event period covering April 24, 1990 to January 10, 1992 . Beta change and volatility change are measured as differences between the event period (January 13, 1992 to September 29, 1993) and the pre-event period. The event period consists of 434 trading days starting five trading days before the first HSA-related event (see Table 4) and ends five trading days after the last HSA-related event. The pre-event period consists of the 434 trading days preceding the event period. For all the variables except advertising, the full sample includes 111 firms and quartiles 1, 2, and 4 include 28 firms. Quartile 3 include 27 firms. For advertising-to-assets the sample is limited to 51 firms, with quartiles 1, 2, 3, and 4 having 17, 20, 11, and 3 firms, respectively.

Variable	Mean	Std. Dev	Variable	Mean	Std. Dev
R&D (millions)			R&D-to-Assets		
Full Sample	60.1482	154.9833	Full Sample	0.2494	0.2664
Quartile 1	47.3005	130.8406	Quartile 1	0.0393	0.0212
Quartile 2	181.3749	242.9518	Quartile 2	0.1104	0.0303
Quartile 3	5.8609	9.6579	Quartile 3	0.2571	0.0533
Quartile 4	4.1176	3.1115	Quartile 4	0.5910	0.3133
Total Assets (millions)			Work Cap.-to-Assets		
Full Sample	661.3324	1711.8500	Full Sample	0.4391	0.2970
Quartile 1	743.8590	1888.0700	Quartile 1	0.3324	0.1960
Quartile 2	1833.1300	2471.4700	Quartile 2	0.3669	0.2692
Quartile 3	31.7168	63.9066	Quartile 3	0.6004	0.3100
Quartile 4	14.1359	11.0630	Quartile 4	0.4626	0.3349
Beta			Cap. Exp.-to-Assets		
Full Sample	1.2763	0.6128	Full Sample	0.0682	0.0632
Quartile 1	0.9883	0.3281	Quartile 1	0.0568	0.0599
Quartile 2	1.2667	0.5391	Quartile 2	0.0938	0.0627
Quartile 3	1.3697	0.6578	Quartile 3	0.0521	0.0605
Quartile 4	1.4841	0.7584	Quartile 4	0.0694	0.0643
Beta Change			Advert.-to-Assets		
Full Sample	0.1003	0.6167	Full Sample	0.0451	0.0777
Quartile 1	0.1527	0.5051	Quartile 1	0.0534	0.0954
Quartile 2	0.0916	0.5454	Quartile 2	0.0938	0.0627
Quartile 3	0.1190	0.7201	Quartile 3	0.0115	0.0143
Quartile 4	0.0388	0.7002	Quartile 4	0.0132	0.0107
Return Volatility			Debt-to-Assets		
Full Sample	0.0420	0.0167	Full Sample	0.1583	0.1833
Quartile 1	0.0347	0.0138	Quartile 1	0.2180	0.1527
Quartile 2	0.0325	0.0186	Quartile 2	0.1744	0.1426
Quartile 3	0.0500	0.0121	Quartile 3	0.0900	0.1476
Quartile 4	0.0512	0.0127	Quartile 4	0.1120	0.1280

Return Volatility Change		
Full Sample	-0.0016	0.0124
Quartile 1	-0.0001	0.0093
Quartile 2	-0.0005	0.0120
Quartile 3	-0.0056	0.0108
Quartile 4	-0.0014	0.0164

Table 2. Cumulative Value-Weighted Returns for a Portfolio of 111 Pharmaceutical and Biotechnology Companies over the 11 Trading Days (5 days before, the event day, and 5 days after) around each HSA-Related Event

Date of Event	Description of HSA-Related Event	Cumulative Return (%)	Z-statistic
January 19, 1992	Clinton issues health care reform proposals before New Hampshire primary.	-7.13	-14.29*
February 18, 1992	Clinton unexpectedly finishes second in the New Hampshire primary.	-3.48	-5.48*
May 10, 1992	Clinton does well in the Super Tuesday primaries.	-3.36	-6.60*
April 7, 1992	Clinton wins New York primary and becomes the favorite to win the Democratic Nomination.	3.73	8.89*
June 4, 1992	Republicans in the House of Representatives offer their health care reform proposal.	-5.19	-10.89*
September 24, 1992	Clinton speaks at Merck on health care reform.	-6.59	-13.24*
November 3, 1992	Clinton wins presidential election.	1.65	1.78
January 25, 1993	Clinton names Hillary Clinton to head his Health Care Task Force.	-5.63	-10.78*
February 12, 1993	Clinton says drug prices are too high.	-11.64	-21.66
September 11, 1993	New York Times describes probable new regulations based upon a leaked copy of plan.	0.24	0.45
September 22, 1993	Clinton officially announces his health care reform plan	-1.16	-3.13*
	Total for the 11 events.	-38.56	-22.51*
	Total for the four events in 1993.	-18.19	-17.65*

* Significant at the 1% level in a two-tailed test.

Table 3. Time Series of the Means of the R&D-to-Assets Regression Variables and Other Variables of Interest Around the Event Period 1992-1993

Dollar figures are adjusted for consumer price inflation (All Urban Consumers-All Items, Base Period 1982-84=100). Return on assets (ROA) is measured as income before extraordinary items divided by assets. Extreme negative ROA observations are set equal to -1. All 111 sample firms have at least eight years of data including 1991-1995. Unexpected RDTA for each firm i in time t, is measured as the error term ($\mu_{i,t}$) from the following regression estimated separately for each firm over the years for which it has annual Compustat data during 1990-2000.

$RDTA_{i,t} = a_0 + a_1(Sales_{i,t}) + a_2(Assets_{i,t}) + a_3(Cash\ Flow_{i,t}) + a_4(Current\ Assets_{i,t}) + a_5(Working\ Capital_{i,t}) + \mu_{i,t}$.

Sample	Year	#Obs.	R&D-to-Assets	Unexpected R&D-to-Assets	R&D (Millions)	Assets (Millions)	Sales (Millions)	Cashflow (Millions)	Current Assets (Millions)	Working Capital (Millions)	Return on Assets
Full Sample	1989	90	0.266	-0.005	64.630	729.070	712.120	120.090	381.980	165.864	-0.214
	1990	108	0.291	0.006	61.331	683.560	646.620	115.075	351.090	125.718	-0.242
	1991	110	0.176	-0.018	68.293	729.740	675.190	117.764	380.850	154.771	-0.174
	1992	109	0.189	-0.014	78.567	777.450	712.110	124.972	401.920	160.603	-0.157
	1993	111	0.251	-0.002	84.433	842.900	717.540	120.489	399.920	147.664	-0.211
	1994	111	0.303	0.005	86.385	1039.440	775.400	138.467	446.800	113.787	-0.245
	1995	111	0.304	0.021	102.092	1125.950	886.940	154.647	478.780	129.883	-0.204
	1996	111	0.235	0.008	108.034	1166.210	959.620	184.886	487.980	138.271	-0.185
Quartile 1	1989	25	0.040	-0.020	49.789	809.070	741.060	118.910	406.490	196.481	0.028
	1990	27	0.041	-0.017	48.166	767.070	689.630	112.730	383.680	181.338	0.007
	1991	27	0.040	-0.016	52.841	795.150	703.960	102.130	409.470	193.958	-0.029
	1992	27	0.055	-0.005	59.018	817.750	703.860	102.280	443.380	223.862	0.032
	1993	28	0.069	0.001	63.393	792.080	697.940	103.300	410.240	190.734	-0.016
	1994	28	0.064	-0.015	68.680	1181.400	747.280	127.280	508.010	187.517	-0.013
	1995	28	0.071	-0.001	88.419	1249.330	900.290	152.430	533.790	195.554	0.007
	1996	28	0.063	-0.007	96.554	1287.710	930.970	140.060	534.020	180.963	-0.066
	1989	24	0.102	-0.022	182.849	1867.540	1893.140	331.380	990.140	393.941	-0.001

Quartile 2											
	1990	27	0.114	-0.036	187.772	1936.580	1889.940	352.770	997.570	301.926	-0.078
	1991	28	0.111	-0.014	205.676	2025.620	1964.870	383.210	1043.010	369.932	-0.031
	1992	28	0.154	-0.011	231.239	2159.350	2077.800	402.660	1082.440	363.464	-0.030
	1993	28	0.232	-0.002	250.741	2460.160	2126.290	386.400	1119.240	349.167	-0.083
	1994	28	0.222	0.020	250.540	2855.830	2301.540	435.450	1213.170	225.508	-0.095
	1995	28	0.218	0.026	289.148	3115.260	2574.420	483.380	1304.860	278.467	-0.028
	1996	28	0.204	0.024	305.459	3218.550	2822.020	602.650	1326.930	315.537	-0.037
Quartile 3	1989	23	0.274	-0.017	4.912	19.480	4.470	-2.180	15.930	14.317	-0.348
	1990	27	0.293	-0.012	5.517	22.350	5.420	-2.040	16.680	14.502	-0.360
	1991	27	0.208	-0.023	7.138	52.200	6.320	-14.920	39.730	34.310	-0.265
	1992	27	0.254	-0.028	11.598	50.680	12.290	-8.400	34.070	28.253	-0.314
	1993	27	0.295	-0.012	12.254	55.720	14.650	-4.070	33.070	26.948	-0.331
	1994	27	0.449	0.036	13.818	54.050	18.270	-5.200	31.030	23.490	-0.400
	1995	27	0.405	0.069	16.781	68.570	33.340	-15.020	39.160	25.982	-0.385
	1996	27	0.341	-0.031	16.806	80.990	41.280	-0.970	47.940	31.437	-0.296
Quartile 4	1989	18	0.790	0.054	3.921	6.690	1.472	-3.755	4.800	3.880	-0.662
	1990	27	0.716	0.089	3.868	8.244	1.508	-3.163	6.411	5.107	-0.537
	1991	28	0.340	-0.019	4.782	24.135	2.753	-4.657	20.040	17.981	-0.369
	1992	28	0.293	-0.012	6.759	30.825	3.928	-6.944	22.589	19.322	-0.321
	1993	28	0.410	0.003	8.767	35.522	6.179	-8.116	24.015	19.494	-0.419
	1994	28	0.484	-0.021	9.909	31.289	7.455	-8.791	20.126	15.411	-0.476
	1995	28	0.527	-0.005	10.975	32.884	9.205	-8.256	21.603	15.819	-0.418
	1996	28	0.337	0.045	10.060	38.831	11.427	-8.838	27.330	21.334	-0.343

Table 4. Regression Estimates for the Cross-sectional Relation between HSA-Related Returns and Expected R&D-to-Assets, Beta, Beta Change, Return Volatility, and Return Volatility Change

The regression is

$HSA\text{-}R_i = b_0 + b_1(ERDTA_{i,t}) + b_2(\beta_{H\,i}) + b_3(\Delta\beta_{H\,i}) + b_4(\sigma_{si}) + b_5(\Delta\sigma_{si}) + \varepsilon_{i,t}$.

HSA-related stock return for firm i (HSA-R) is the firm's cumulative return for the four 1993 HSA-related events listed in Table 3. Expected R&D-to-Assets (ERDTA) is measured as the fitted values from the regression in equation (7) for each firm estimated over the years for which it has annual Compustat data during 1980-2000. All 111 sample firms have at least eight years of data including 1991-1995. Beta ($\beta_{H\,i}$) and return volatility (σ_{si}) are measured for each sample firm i over the pre-event period (April 24, 1990 to January 10, 1992). Beta change ($\Delta\beta_{H\,i}$) and return volatility change ($\Delta\sigma_{si}$) are measured as differences for firm betas or return volatilities between the event period (January 13, 1992 to September 29, 1993) and the pre-event period. The event period consists of 434 trading days starting five trading days before the first HSA-related event (see Table 4) and ends five trading days after the last HSA-related event. The pre-event period consists of the 434 trading days preceding the event period. Liquid asset intensity (L) is measured as net working capital divided by total assets. Price constraint $dummy_i$ (PCD) equals 1 if firm i pledged to keep its price increases below the inflation rate and equals zero otherwise. Regressions are estimated using ordinary least squares with t-statistics in parentheses

Sample	Intercept	ERDTA	β_H	$\Delta\beta_H$	σ_{si}	$\Delta\sigma_s$	β_H x L	$\Delta\beta_H$ x L	σ_{si} x L	$\Delta\sigma_s$ x L	PCD	R^2	F-stat
1993	-0.03	-0.04	-0.12*	-0.08**	2.14	-0.57						0.13	3.20*
	(-0.39)	(-0.69)	(-3.45)	(-2.24)	(1.62)	(-0.33)							
1994	-0.04	-0.13**	-0.11*	-0.08*	2.86**	-0.25						0.17	4.11*
	(-0.67)	(-2.10)	(-3.15)	(-2.35)	(2.17)	(-0.15)							
1995	-0.03	-0.06	-0.12*	-0.07**	2.29***	-0.71						0.14	3.34*
	(-0.44)	(-1.03)	(-3.40)	(-2.14)	(1.74)	(-0.43)							
1994	-0.12	-0.16*	0.03	0.08	-0.11	-3.16	-0.34*	-0.34*	11.55*	10.32**		0.28	4.25*
	(-1.66)	(-2.65)	(0.51)	(1.30)	(-0.07)	(-1.20)	(-3.02)	(-2.93)	(3.51)	(2.11)			
1994	-0.12	-0.16*	0.03	0.08	-0.28	-3.17	-0.34*	-0.34*	11.67*	10.22**	-0.01	0.28	3.79*
	(-1.45)	(-2.64)	(0.54)	(1.29)	(-0.15)	(-1.19)	(-2.98)	(-2.93)	(3.47)	(2.07)	(-0.20)		

*,**, and *** denote estimate significance at the 1, 5, and 10 percent levels, respectively, in a two-tailed test.

Table 5. Regression Estimates for the Cross-sectional Relation between Unexpected R&D-to-Assets, and HSA-Related Return, Beta Change, and Return Volatility Change

The regression is

$URDTA_{i,t} = b_0 + b_1(HSA\text{-}R_i) + b_2(\Delta\beta_{Hi}) + b_3(\Delta\sigma_{si}) + \varepsilon_{i,t}$.

Unexpected R&D-to-Assets (URDTA) is measured as the residual values from the regression in equation (7) for each firm estimated over the years for which it has annual Compustat data during 1980-2000. All 111 sample firms have at least eight years of data including 1991-1995. Expected R&D-to-Assets (ERDTA) is measured as the fitted values from the same regression. HSA-related stock return for firm i (HSA-R) is the firm's cumulative return for the four 1993 HSA-related events listed in Table 3. Beta change ($\Delta\beta_{Hi}$) and return volatility change ($\Delta\sigma_{si}$) are measured as differences for firm betas or return volatilities between the event period (January 13, 1992 to September 29, 1993) and the pre-event period (April 24, 1990 to January 10, 1992). The event period consists of 434 trading days starting five trading days before the first HSA-related event (see Table 4) and ends five trading days after the last HSA-related event. The pre-event period consists of the 434 trading days preceding the event period. Liquid asset intensity (L) is measured as net working capital divided by total assets. Price constraint $dummy_i$ (PCD) equals 1 if firm i pledged to keep its price increases below the inflation rate and equals zero otherwise. Regressions are estimated using ordinary least squares with t-statistics in parentheses.

Sample	Intercept	HSA-R	$\Delta\beta_H$	$\Delta\sigma_s$	$\Delta\beta_H$ x L	$\Delta\sigma_s$ x L	PCD	R^2	F-stat
1993	-0.01	0.04	0.04**	-0.51				0.08	3.22**
	(-0.26)	(0.78)	(2.85)	(-0.65)					
1994	0.01	0.13**	0.06*	-0.75				0.14	5.63*
	(1.00)	(2.27)	(3.20)	(-0.85)					
1995	0.03**	0.09	0.01	1.83***				0.04	1.64
	(2.32)	(1.36)	(0.59)	(1.82)					
1994	0.02	0.14**	-0.01	-1.17	0.14**	1.74		0.18	4.62*
	(1.32)	(2.45)	(-0.16)	(-0.72)	(2.36)	(0.57)			
1994	0.02	0.14**	-0.01	-1.18	0.14**	1.74	0.01	0.18	3.82*
	(1.25)	(2.44)	(-0.15)	(-0.72)	(2.34)	(0.57)	(0.07)		

*,**, and *** denote estimate significance at the 1, 5, and 10 percent levels, respectively, in a two-tail test.

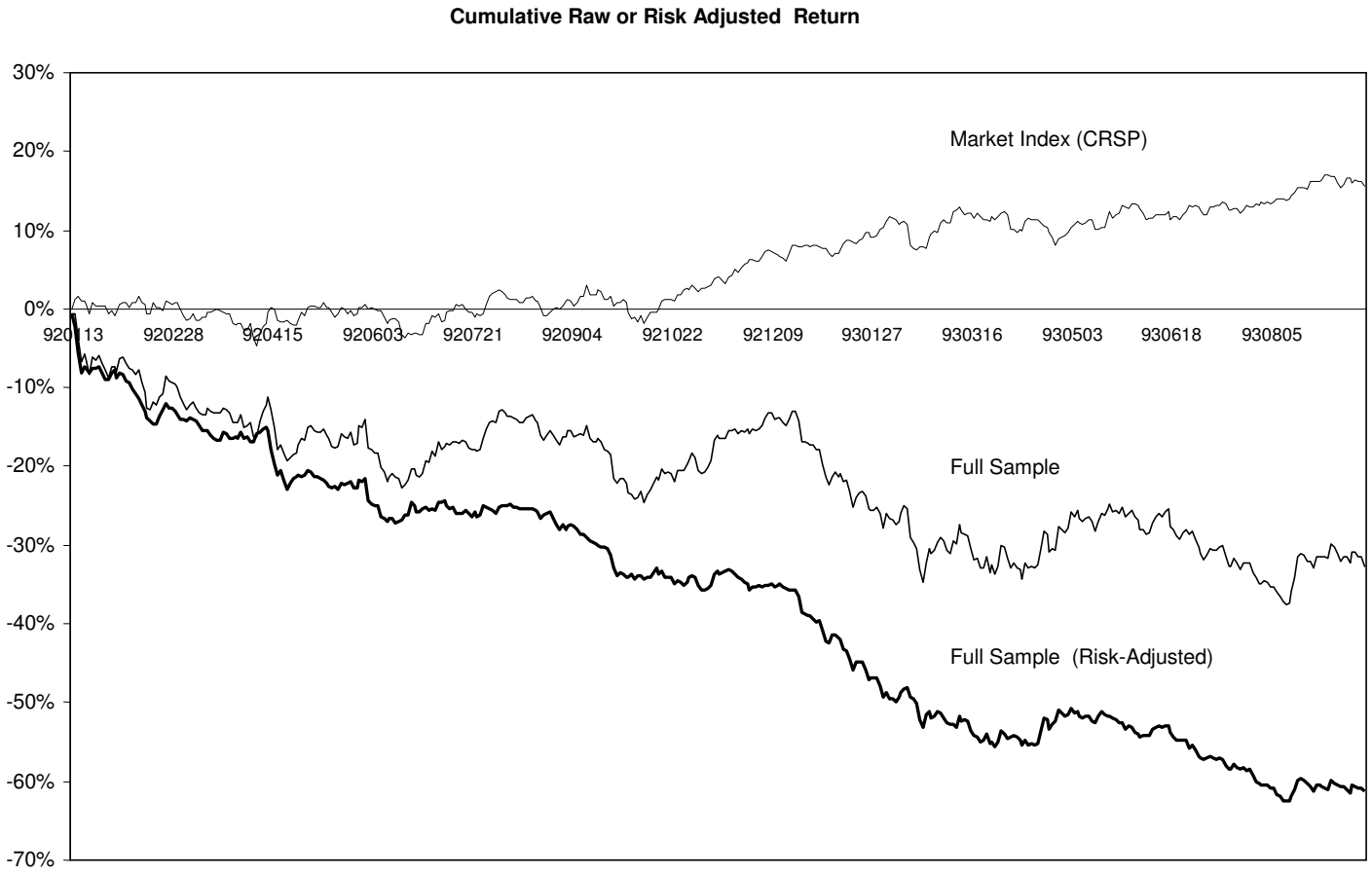

Figure 1. A Comparison of the Value-Weighted Returns during the HSA Event Period from January 13, 1992 to September 29, 1993 for the Stock Market and a Sample of 111 Pharmaceutical and Biotechnology Stocks

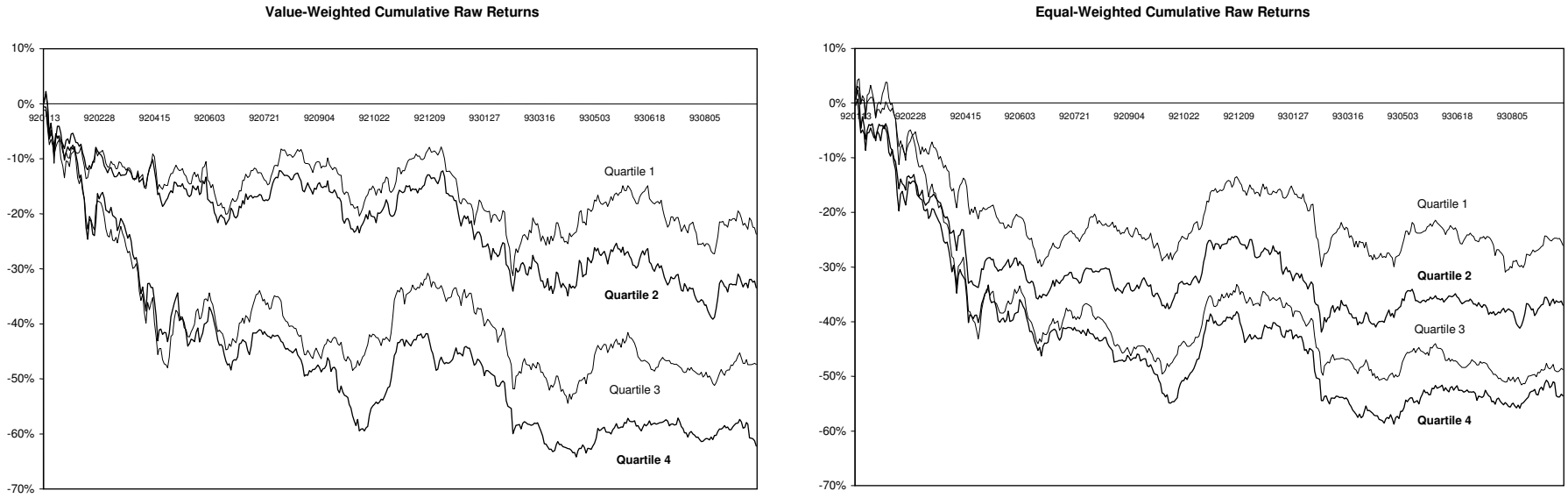

Figure 2. – Raw Returns during the HSA Event Period from January 13, 1992 to September 29, 1993 for 111 Pharmaceutical and Biotechnology Stocks Sorted by R&D-to-Assets into Quartiles

Figure 3. – Risk-Adjusted Returns during the HSA Event Period from January 13, 1992 to September 29, 1993 for 111 Pharmaceutical and Biotechnology Stocks Sorted by R&D-to-Assets into Quartiles

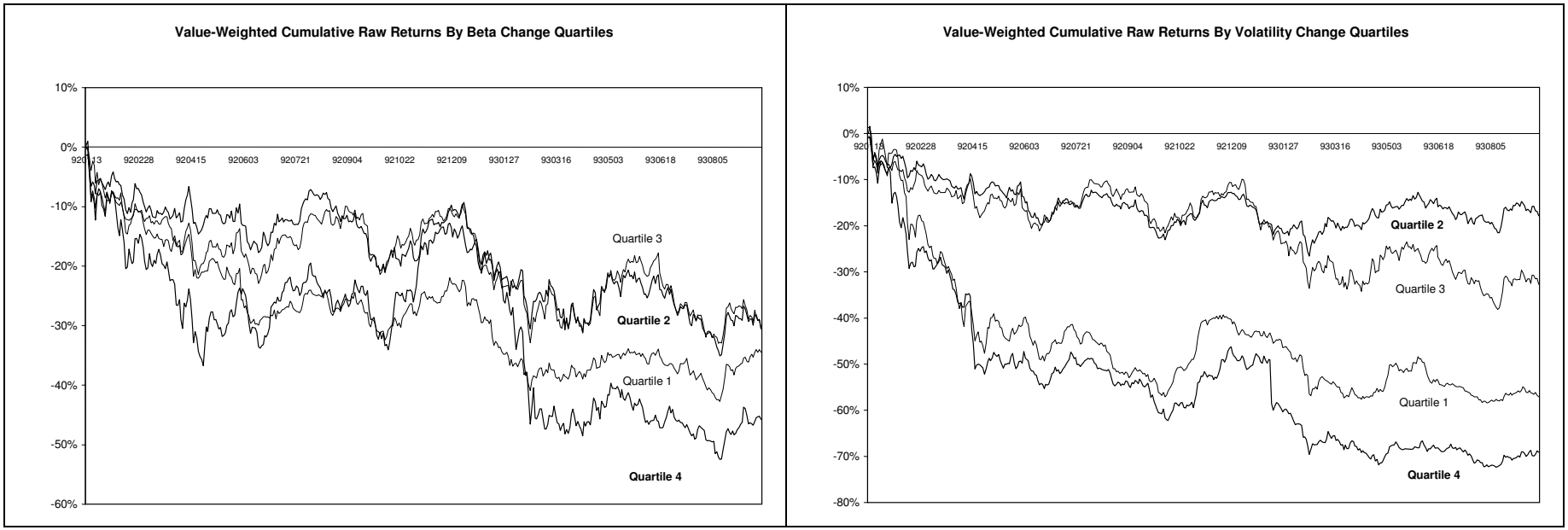

Figure 4. – Raw Returns during the HSA Event Period from January 13, 1992 to September 29, 1993 for 111 Pharmaceutical and Biotechnology Stocks Sorted by Either Beta Change or Return Volatility Change into Quartiles

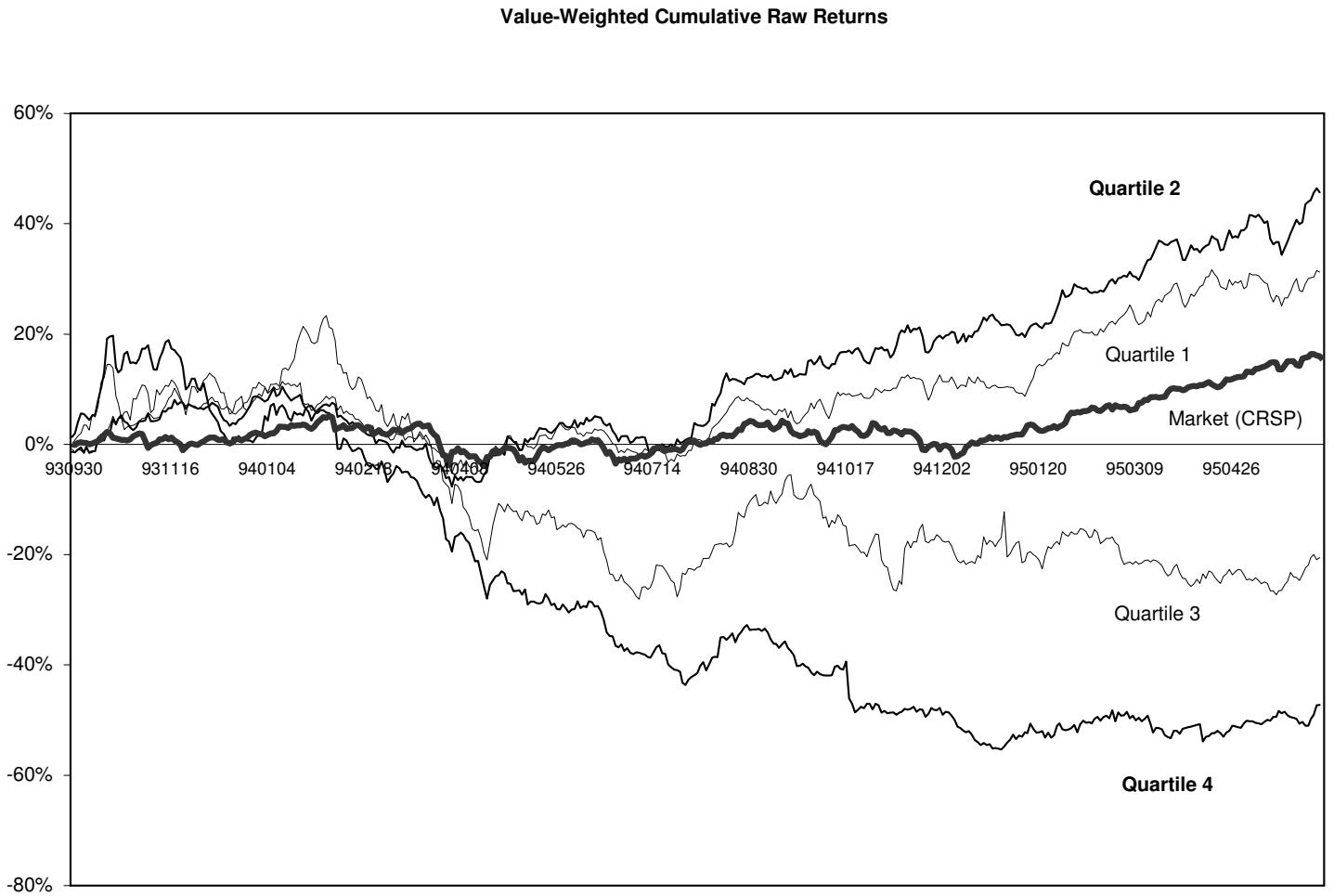

Figure 5. Raw Returns after the HSA Event Period from September 30, 1993 to June 20, 1995 for the Stock Market and a Sample of 111 Pharmaceutical and Biotechnology Stocks Sorted by R&D-to-Assets into Quartiles