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Information Asymmetry, R&D, and Insider Gains

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ABSTRACT

Although researchers have documented gains from insider trading, the sources of private information leading to information asymmetry and insider gains have not been comprehensively investigated. We focus on research and development (R&D)—an increasingly important yet poorly disclosed productive input—as a potential source of insider gains. Our findings, for the period from 1985 to 1997 indicate that insider gains in R&D-intensive firms are substantially larger than insider gains in firms without R&D. Insiders also take advantage of information on planned changes in R&D budgets. R&D is thus a major contributor to information asymmetry and insider gains, raising issues concerning management compensation, incentives, and disclosure policies.

Researchers have documented that "corporate insiders," defined by the 1934 Securities and Exchange Act as corporate officers, directors, and owners of 10 percent or more of any equity class of securities, gain from trading in the securities of their firms.[1] However, the specific *sources* of information leading to insider gains in particular and to information asymmetry in general have not been comprehensively investigated. An identification of the sources of insiders' information contributes to our knowledge in various ways. For example, researchers often use proxies for the extent of information asymmetry, such as the number of analysts following a firm, the number of competing traders, or insiders' and institutional ownership (e.g., Stoll (1978),

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[1] Estimates of the gains from insider trading vary widely: Early studies (e.g., Lorie and Niederhoffer (1968), Jaffe (1974), and Finnerty (1976)) report abnormal gains ranging from 3 to 30 percent, for holding periods of up to three years. Seyhun (1986), using data on insider trading reported to the SEC during 1975 through 1981, finds more modest gains to insiders: Over 300 days subsequent to trade, the average risk-adjusted gains were 4.3 percent for stock purchasers and 2.2 percent for sellers. Most of these gains occurred during the first 100 days after trade. In a subsequent study, Seyhun (1992) documents for the period from 1975 to 1989 average abnormal returns to insiders of 2.6 percent for six months after stock purchases, and 5.3 percent for six months following sales. Jeng, Metrick, and Zeckhuser (1999), using value-weighted portfolio schemes for the period from 1975 to 1996, report for a one year holding period insider gains on purchases of roughly 0.4 percent abnormal returns per month and insignificant abnormal returns for sales.

Brennan and Subrahmanyam (1995)). Additional information asymmetry proxies are firm size and volume of trade (Chari, Jagannathan, and Ofer (1988)), financial analysts' forecast errors of earnings, and the volatility of abnormal stock returns (e.g., Krishnaswami and Subramaniam (1999)). Such proxies are obviously noisy, reflecting, in addition to information asymmetry, numerous firm and market attributes. Identification of the major sources or firm-specific drivers of information asymmetry will suggest more precise (less noisy) measures of asymmetry. For policy research concerned with the social consequences of insider gains and information asymmetry, identification of the sources of insiders' information will suggest means (e.g., enhanced disclosure of specific information) of mitigating harmful consequences.[2]

We investigate the insider gains issue from the perspective of a specific source of information asymmetry—research and development (R&D). Investment in R&D is a major productive input in a large number of firms, particularly those operating in the technology and science-based sectors. R&D, however, differs from other capital and financial inputs (e.g., property, plant, and equipment, inventory, or project financing) along several important dimensions related to information asymmetry. First, many R&D projects, such as radically new drugs under development or software programs are *unique* to the developing firm, whereas most capital investments, such as commercial property or airplanes, share common characteristics across firms within an industry. Consequently, investors can derive little or no information about the productivity and value of a firm's R&D from observing the R&D performance of other firms (e.g., not much can be learned about Merck's drug development program from an FDA approval of a Pfizer drug), whereas, for example, the average store performance of one retailer provides valuable information on the performance of other retailers. Second, while most physical and financial assets are traded in organized markets, where prices convey information about asset productivity and values, there are no organized markets for R&D and hence no asset prices from which to derive information. Third, accounting measurement and reporting rules treat R&D differently from other investments: While these rules mandate the marking-to-market in quarterly and annual reports of most financial investments, and the periodic recognition of value impairment (the decrease of market value below cost) of physical assets, thereby providing investors with updated information about changes in asset values, R&D is immediately expensed in financial statements, so that no information on value and productivity changes of R&D is reported to investors.

[2] See Fried (1998) for a summary of the debate about the social consequences of insider gains and the effectiveness of securities regulations aimed at limiting these gains. The spectrum of opinions about social consequences ranges from viewing insider trading as desirable (e.g., it enhances market efficiency) to viewing insider gains as detrimental to firms (increase cost of capital, distort managerial incentives) and eroding investors' confidence in the integrity of capital markets. See also Jeng et al. (1999) who conclude that under the current regulatory system outsiders are not significantly disadvantaged when trading with insiders.

Given the relative scarcity of public information about firms' R&D activities, and the importance of these activities to the operations and profit potential of technology and science-based companies, we hypothesize that R&D contributes to information asymmetry between corporate insiders and outside investors and that some of the former will exploit this asymmetry to gain from insider trading.[3] Indeed we find from comprehensive data on corporate officers' share trading from 1985 to 1997 that insider gains in firms conducting R&D (R&D firms) are substantially larger than insider gains in firms with no R&D activities (No-R&D firms). These differences in insider gains are both statistically and economically significant, and hold after controlling for various known risk factors. We also find that investors' reaction to the public disclosure of insiders' trade (about a month, on average, after the trade) is stronger for R&D firms than for No-R&D firms, corroborating our hypothesis that R&D activities enhance information asymmetry, and that this asymmetry is not eliminated by insiders' trade and investors' information search. We thus identify R&D as a major contributor to information asymmetry.

The paper is organized as follows. In Section I we develop our hypothesis and in Section II we describe the sample and summary statistics. Section III presents the estimation equations and reports empirical findings on the association between insider gains and firms' R&D intensity. In Section IV we examine investors' reaction to the public disclosure of insider trades, and in Section V we present robustness tests. Section VI concludes the study.

I. Information Asymmetry, R&D, and Insider Gains

All corporate investments create information asymmetries because managers can continually observe changes in investment productivity on an *individual* asset basis (e.g., aircraft utilization—load factor—at the route level), whereas outsiders obtain only highly aggregated information on investment productivity at discrete points of time. The extent of information asymmetry associated with R&D, however, is larger than that associated with tangible (e.g., property, plant, and equipment) and financial investments because of the relative uniqueness (idiosyncrasy) of R&D. Thus, for example, a failure of a drug under development to pass Phase I clinical tests, or of a software program to successfully complete an alpha (technological feasibility) test in a particular company are unique events not shared by other pharmaceutical or software companies. In contrast, a downturn in demand for commercial

[3] A perspective on the importance of R&D as a productive input can be gained from the fact that in 1997 total R&D spending in the United States was $210 billion, compared with $215 billion invested by manufacturing firms in property, plant, and equipment. The increasing importance of R&D is also reflected by its faster growth rate compared with other major inputs. For example, over the period from 1970 to 1997, the average annual growth rate of R&D was 8.0 percent, whereas the growth rate of capital investment (property, plant, and equipment) was 6.8 percent (see Economic Report of the President, 1997, and National Science Foundation/SRS).

properties, for example, will exert a strong common effect on the property values of all real estate companies operating in a given geographical region. Similarly, interest-rate changes will affect systematically the values of bond and stock portfolios of companies. Thus, we argue, the relative uniqueness of R&D investments makes it difficult for outsiders to learn about the productivity and value of a given firm's R&D from the performance and products of other firms in the industry, thereby contributing to information asymmetry.[4]

The absence of *organized markets* in R&D further contributes to information asymmetry. Whereas investors can derive considerable information from prices of traded tangible and financial assets concerning their values at the firm level (e.g., inferring from changes in commodity prices about swings in values of firms' inventories), there is no direct price-based information on firm-specific changes in the value and productivity of R&D.[5] Some information on R&D can, of course, be inferred from stock prices of R&D-intensive companies, yet such information is noisy, given the multiple activities of R&D firms (e.g., manufacturing, services).

Accounting rules exacerbate the information asymmetries associated with R&D. Most financial assets have to be marked-to-market in quarterly and annual financial reports, and impairments in the values of tangibles assets (i.e., when expected future benefits fall short of book values) have to be routinely reported in financial statements. Similarly, inventories and accounts receivable have to be written down in financial reports to market values. Thus, investors are periodically informed about changes in the values of most tangible and financial assets. In contrast, R&D expenditures are uniformly expensed in financial reports and therefore no information is required to be provided to outsiders about changes in the productivity and value of R&D. Even major R&D events, such as when a drug under development successfully passes clinical tests, are not routinely reported to investors.

Empirical evidence is consistent with a relatively large information asymmetry associated with R&D. For example, Barth, Kasnik, and McNichols (1998) report that analyst coverage (number of analysts following a firm) is significantly larger for firms intensive in R&D relative to firms with lower or no R&D, presumably because of the private information concerning R&D

[4] The uniqueness of R&D is widely recognized in economics and finance research. Thus, for example, Titman and Wessels (1988, p. 5) postulate that asset uniqueness is a determinant of corporate capital structure and measure uniqueness by R&D intensity, arguing that R&D "measures uniqueness because firms that sell products with close substitutes are likely to do less research and development since their innovations can be more easily duplicated. In addition, successful research and development projects lead to new products that differ from those existing in the market."

[5] Griliches (1995, p. 77) notes: "A piece of equipment is sold and can be resold at a market price. The results of research and development investments are by and large not sold directly . . . the lack of direct measures of research and development output introduces an inescapable layer of inexactitude and randomness into our formulation." Such randomness and inexactitude are obviously less severe to insiders than to outsiders.

activities. Furthermore, analysts' *efforts* and, presumably, costs of analyzing firms vary positively with R&D intensity.[6] Similarly, Tasker (1998) reports that R&D-intensive companies conduct more conference calls with analysts than low (or no) R&D firms, implying a stronger investors' demand for information about the R&D activities of firms.[7]

Is all the private R&D-related information shared in a timely manner with outsiders through the information search of analysts and investors, so that in equilibrium there are no substantial information asymmetries left? Kyle's (1985) model of a single informed trader with many uninformed (noise) traders and a market maker addresses this question and indicates that in equilibrium: (1) "The informed trader trades in such a way that his private information is incorporated into prices *gradually*." (p. 1316, emphasis ours), and (2) "not all information is incorporated into prices by the end of trading." (p. 1326). The main conclusion of the model is that, while much of the insider's information gets gradually incorporated in prices through his/her trades, the "*insider makes positive profits* by exploiting his monopoly power optimally in a dynamic context. . ." (p. 1315, emphasis ours).[8]

Particularly relevant to our hypothesis concerning R&D-related information asymmetry and the consequent insider gains is Kyle's (1985) conclusion that insiders' profits are proportional to $(\Sigma_0 \sigma_u)^{1/2}$, where Σ_0 is the variance of the liquidation value of the risky asset. We know from Kothari, Laguerre, and Leone (1998) that: ". . . R&D investments generate more uncertain future benefits than investment in tangible assets. Specifically, in a regression of future earnings variability on investment in R&D, PP&E [property, plant, and equipment] and other determinants of earnings variability like firm size and leverage, we find that the coefficient on R&D is about three times as large as that on PP&E." Thus, the documented larger variability of earnings and, by implication, firms' liquidation value associated with R&D should, according to Kyle (1985), enhance the gain of insiders in R&D firms, relative to insiders in No-R&D firms with lower variability of earnings.

[6] Analysts' efforts were proxied by Barth et al. (1998) by the number of other firms followed by a given firm's analysts. Assuming that analysts have a common capacity limit and expend efforts up to that capacity, the smaller the number of firms an analyst follows, the larger, on average, the efforts spent analyzing those firms.

[7] Tasker (1998b) also reports that the majority of questions raised by analysts in conference calls involve R&D-related issues, such as the content of the company's product pipeline.

[8] Kyle's (1985) predictions are sensitive to the number of informed traders. For example, Back, Cao, and Willard (1999) conclude: "Competition may or may not lead to greater 'efficiency' of prices. Whether the market price reflects private information more quickly when there are competing informed traders depends on how the information is distributed among the agents. Indeed, in this model, it is never the case that the market is *always* more efficient when information is distributed among competing traders than when the information is possessed by a single trader" (p. 30). "A somewhat surprising result is that, beyond some date, the market would have learned more from a monopolist informed trader than from competing traders, regardless of the correlation of the competitors' signals" (p. 2). "The relatively large amount of private information remaining near the end of trading leads to an extreme adverse selection problem" (p. 3).

Kyle's second (1989) model is particularly relevant to our case, because it allows uninformed investors to acquire private information. Among the conclusions of this model are: (1) "thus, while uninformed speculators break even on average, informed speculators make money 'at the expense' of noise traders . . ." (p. 337), (2) "with imperfect competition, prices never reveal more than one-half the private precision of informed speculators." (p. 334), and (3) "in order for the large market model to reveal any private information, private information must be cheap enough so that a large number of speculators find it profitable to purchase it." (p. 344). Thus, even with endogenous information acquisition, insiders are expected to gain from insider trading.

Given the importance of R&D in firms' productivity and growth, it is reasonable to expect investors and analysts to acquire private R&D-related information from managers, as the evidence discussed above indicates. However, because such information is costly, requiring among other things a significant investment in scientific knowledge (e.g., understanding genome research in biochemistry) and a considerable time investment (e.g., analyzing financial reports, participating in conference calls), optimal information acquisition by outsiders will generally fall short of completely exhausting insiders' information. Stated differently, in equilibrium the marginal value of acquired information will equal marginal cost, but this does not necessarily imply that the *total* R&D information possessed by managers will be quickly incorporated in prices, leaving managers with no opportunities to gainfully trade on inside information. Indeed, our evidence (Sec. IV) indicates a significant market reaction to the *disclosure* of insiders' trades (25 days, on average, subsequent to the actual trades), a reaction that is more pronounced for R&D than for No-R&D companies, implying that almost a month after trade by insiders and the extensive information search by outsiders, prices still did not fully reflect all of insiders' private information.

We accordingly hypothesize in this study that the R&D activities of firms create unique information asymmetries and that officers of R&D companies will gainfully exploit these asymmetries by trading the shares of their firms.

II. Data Sources and Sample Characteristics

The insider trading data analyzed in this study were obtained from CDA/Investnet. The database contains all purchase and sale transactions made by insiders and reported to the SEC from January 1985 through December 1997.[9] We focus on 323,949 open market purchase and sale transactions that were conducted by *officers* of firms, as officers are a priori presumed to have

[9] The enforcement of the Securities and Exchange Act of 1934 was considerably strengthened by the Insider Trading Sanctions Act of 1984 (see Bainbridge (1998)), providing a reason to start the sample period in 1985.

inside information on R&D.[10] We delete 732 duplicate transactions and change of control transactions where the number of shares exchanged exceeded 20 percent of the total shares outstanding. We also delete 2,334 companies with 31,417 officer transactions that could not be located on the CRSP database, and 1,459 firms with 29,897 transactions that were not found on COMPUSTAT. Finally, we delete 8,865 insider transactions because of missing data on R&D in COMPUSTAT, resulting in a final sample of 253,038 transactions related to 10,013 firms.

Table I provides sample statistics by type of insider transaction and year. Of the 10,013 sample firms, 3,818 are classified as R&D firms and 6,195 are classified as No-R&D firms; the latter are those for which COMPUSTAT does not report any R&D expenditures during the period from 1985 to 1997. Consistent with prior studies, the total number of sale transactions (165,949; 81,539 for R&D and 84,410 for No-R&D firms) is almost twice the number of purchase transactions (87,089). The difference between purchase and sale transaction (number and value), however, is substantially larger for R&D firms (23,008 vs. 81,539) than for No-R&D firms (64,081 vs. 84,410), reflecting the pervasiveness of stock options and awards (included in sales but not in purchases) in R&D companies. The number and volume of insider transactions has increased continuously during the period from 1985 to 1997, and the increase in transaction values for R&D firms has been proportionately larger than for No-R&D firms. The three transaction measures—number of transactions, number of shares, and total value of transactions—are highly correlated. In the tests reported below we use the number of shares transacted. Replication of the tests with dollar value of transactions yielded very similar results to those derived from the number of shares.

Panel B of Table I reports mean and median market-adjusted returns (raw return minus the return on a value-weighted NYSE/AMEX/Nasdaq index) for three intervals subsequent to insider transactions: From transaction date to 1 day before the transaction's filing with the SEC (an average of 25 days in our sample) and 6 and 12 months following the transaction. The excess return data indicate that, on average, insider share purchases were followed by positive returns in each interval, whereas share sales were followed by negative returns. Thus, insiders in both R&D and No-R&D companies tend to buy shares ahead of good news and sell ahead of bad news. However, both the mean and median excess returns of R&D firms are significantly higher for purchase and lower for sale transactions than returns of firms without R&D activities. Thus, for example, the mean market-adjusted return from transaction to SEC filing date of insider purchases in R&D firms was 3.0 percent versus 0.9 percent for share purchases in No-R&D firms. Note that

[10] The database we use includes several types of transactions we did not consider because it is not clear to what extent they are motivated by inside information. These transactions include: Acquisition of stocks through company plans, gifts of stocks, acquisitions through dividend reinvestment plans and under employee benefit plans. Examples of nonofficer insiders we exclude from the sample are various trustes and owners without managerial capacity.

Table I

Distribution of Insider Transactions and Market-Adjusted Returns, January 1985–December 1997

All means and medians in Panel B are significantly different from zero at the one percent level and significantly different between R&D and No-R&D firms at the five percent level. Market adjusted returns are the raw returns minus the return on a value weighted NYSE/AMEX/Nasdaq index. No-R&D firms are those for which COMPUSTAT does not report R&D expenditures in any quarter during 1985–1997.

Panel A: Transaction Data

	Jan. 1985–Dec. 1989		Jan. 1990–Dec. 1993		Jan. 1994–Dec. 1997		1985–1997	
	R&D	No-R&D	R&D	No-R&D	R&D	No-R&D	R&D	No-R&D
No. of transactions								
No. of purchases	7,027	17,124	7,004	21,794	8,977	25,163	23,008	64,081
No. of sales	18,255	21,585	28,018	29,150	35,266	33,675	81,539	84,410
Total no. of transactions	25,282	38,709	35,022	50,944	44,243	58,838	104,547	148,491
No. of shares (millions)								
No. of shares purchased	51.1	150.4	110.4	246.7	150.5	329.3	312.0	726.4
No. of shares sold	222.0	383.7	392.6	567.6	572.4	869.9	1,187.0	1,821.2
Total no. of shares traded	273.1	534.1	503.0	814.3	722.9	1,199.2	1,499.0	2,547.6
Value of transactions ($ millions)								
Val. of shares purchased	366.7	2,257.8	311.4	1,599.2	699.8	2,855.7	1,377.9	6,712.7
Val. of shares sold	3,386.2	5,213.6	8,544.8	10,725.4	16,190.5	18,489.4	28,121.5	34,428.4
Total val. of shares traded	3,752.9	7,471.4	8,856.2	12,324.6	16,890.3	21,345.1	29,499.4	41,141.1

Panel B: Return Data

	R&D Firms				No-R&D Firms			
	Purchases		Sales		Purchases		Sales	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Market-adjusted return from transaction to SEC filing date	3.0%	0.7%	−0.5%	−0.2%	0.9%	0.07%	−0.1%	−0.1%
Market-adjusted return over 6 months following the transaction date	9.61%	1.0%	−4.1%	−7.1%	3.56%	0.2%	−3.8%	−4.6%
Market-adjusted return over 12 months following the transaction date	8.56%	1.93%	−10.0%	−14.0%	2.47%	0.36%	−8.6%	−9.2%

the 3.0 percent excess return for R&D firms is economically large, given that the mean interval between transaction and filing dates is 25 days only. For insider sales, the mean market-adjusted return over the transaction-filing interval for R&D firms was −0.5 percent versus −0.1 percent for No-R&D firms.

The posttransaction returns generally increase from the first interval (transaction to SEC filing date) to the second interval (6 months following trade), and further increase for the third interval (12 months following trade). During six months following trade, excess mean returns from share purchases for R&D firms were 9.61 percent versus 3.56 percent for No-R&D firms. All the differences between mean (median) returns of R&D versus No-R&D firms in Table I are statistically significant at the 5 percent level.

The return data in Table I are consistent with our hypothesis: Insider gains in R&D-intensive companies are substantially higher than insider gains in No-R&D companies. However, the underlying individual transaction data are not independent (there are multiple transactions per firm), and the returns over the 6 and 12 months intervals are overlapping. Moreover, firm attributes (e.g., risk, size) related to R&D may affect the documented returns, in addition to the hypothesized information asymmetry differences.

Accordingly, the return data in Table I should be viewed as descriptive and tentative, and we proceed below to aggregate insider transactions by firms, considering only no overlapping return intervals and controlling for known risk factors.

III. Insider Gains and R&D

We wish to examine the association between insider gains and information asymmetry as proxied by the firm's R&D intensity. To accomplish this we construct four monthly calendar-time portfolios conditional on the firms' R&D activities and the type of insiders' transactions (purchase or sale). The four portfolios are: (1) RD_p, for firms engaged in R&D whose insiders were "net purchasers" of shares in a given month during the period from 1985 to 1997 (a net purchaser firm-month is one where the number of shares purchased by the firm's officers during the month exceeded the number of shares sold); (2) RD_s, for firms engaged in R&D whose insiders were "net sellers" of shares (i.e., number of shares sold by insiders during the month exceeded purchases); (3) $NORD_p$, for firms without R&D whose insiders were net purchasers; and (4) $NORD_s$, for firms without R&D whose insiders were net sellers of shares.[11]

We calculate returns for each of the four portfolios as follows. For each calendar month (January 1985 through November 1997, a total of 155 months) we compute a *firm-specific* mean raw return from the transaction dates of insiders' trades to one day prior to the filing date of those transactions with

[11] In the large majority of sample firm-month cases, insider trades were either all sales or all purchases.

the SEC. These firm-specific transaction-to-reporting returns are averages over all the individual insider trades that occurred during the month. We then compute calendar-time equally weighted portfolio returns over all the firms with insider transactions in a given month, classified into the four portfolios described above, namely firms with and without R&D, where insiders during the month were net stock purchasers or net sellers.[12] We thus focus on portfolio returns over the transaction-to-SEC filing period, during which information asymmetry is presumably large. The public disclosure of insiders' trade substantially decreases information asymmetry, as evidenced by investors' reaction to this information (Sec. IV).

To examine the extent to which insiders in R&D firms gain more than those in No-R&D firms, we employ an intercept test using the three-factor model of Fama and French (1993). The dependent variable is the difference between calendar-time portfolio returns of R&D and No-R&D firms ($RD_{pt} - NORD_{pt}$). For example, for our first month, January 1985, RD_{pt} is the average return for all R&D firms whose officers were net purchasers of shares during January 1985, over the transaction-to-filing interval. $NORD_{pt}$ is the average return for all firms without R&D whose officers were the net purchasers of shares during January 1985, over the transaction-to-filing interval. The regression is run over 155 observations—individual months during January 1985 to November 1997. The independent variables are the three factors: Market return, size, and book-to-market. The regression is thus:

$$RD_{pt} - NORD_{pt} = \alpha_p + \beta_p(R_{mt} - R_{ft}) + \delta SMB_t + \sigma_p HML_t + \epsilon_p, \qquad (1)$$

where

$RD_{pt} - NORD_{pt}$ = return from going long on a portfolio of firms that engage in R&D and short on a portfolio of firms that do not engage in R&D, in months where insiders were net purchasers of shares. The return interval is between transaction date and one day prior to SEC filing date—25 days on average.

$R_{mt} - R_{ft}$ = the market excess return in month t.

SMB_t = the difference between month t return on a value-weighted portfolio of small stocks and one of large stocks.

HML_t = the difference between month t return on a value-weighted portfolio of high book-to-market stocks and one of low book-to-market stocks.[13]

[12] We replicate our tests with value-weighted portfolio returns and obtained very similar results to those of the equally-weighted returns.

[13] The construction of these variables is described in Fama and French (1993). We thank Ken French for providing us the data for the independent variables in equation (1).

Table II

Returns from Going Long on Insider Trading in R&D Firms and Short on No-R&D Firms

Panel A presents mean and median percentage raw returns earned on portfolios formed as follows: For each month between January 1985 and November 1997 we calculate, for each sample firm, the mean raw return from the insider transaction date to one day prior to the SEC filing date, over all insider transactions during the month. We calculate the mean returns separately for firms with and without R&D, and for firms where insiders were net purchasers during the month (i.e., share purchases exceeded sales) and firms where insiders were net sellers during the month. # > 0 indicates number of months (out of 155) when the mean return was positive. In Panel B, the intercept (α) of the Fama-French three-factor model in equation (1) is presented. It is the estimated intercept from a time series regression (155 observations) of the portfolio returns of firms with R&D minus the portfolio return of firms without R&D ($RD - NORD$) on the market excess return ($RM - RF$), a zero-investment size portfolio (SMB), and a zero-investment book-to-market portfolio (HML).

Panel A: Univariate Returns

	Insider Purchases			Insider Sales		
	Mean	Median	# > 0	Mean	Median	# > 0
Firms with R&D	5.49%***	4.64%***	136	−1.26%***	−1.17%***	57
Firms without R&D	4.57%***	3.82%***	133	−0.66%***	−0.44%**	67
$RD_t - NORD_t$	0.92%***	1.66%***	96	−0.60%***	−0.70%***	53

Panel B: Three-factor Model

	α	$RM_t - RF_t$	SMB_t	HML_t	Adjusted R^2
Insider Purchases					
$RD_t - NORD_t$	0.011**	−0.129	0.491**	−0.364	0.056
t-statistic	(2.40)	(−1.01)	(2.65)	(−1.56)	
Insider Sales					
$RD_t - NORD_t$	−0.005*	0.088	0.232**	−0.072	0.043
t-statistic	(−1.85)	(1.24)	(2.24)	(−0.55)	

*, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

An identical regression to equation (1) was run for portfolios of insider *sales*: $RD_{st} - NORD_{st}$.

Panel A of Table II presents the univariate raw returns for the four portfolios examined. Consistent with prior research, we observe for all trades positive stock returns subsequent to insiders' share purchases and negative returns subsequent to insiders' sales. As hypothesized above, both the mean and median returns on the R&D portfolios are significantly higher than returns on the No-R&D portfolios when insiders purchased shares and lower when they sold shares. Investing long in a portfolio of R&D firms whose insiders purchased shares and short in a portfolio of No-R&D firms whose insiders purchased shares ($RD_t - NORD_t$) yields a mean (median) return of 0.92 percent (1.66 percent) over an average of 25 days between transaction

and SEC filing dates.[14] The insider sales portfolios yield a differential mean (median) return of −0.60 percent (−0.70 percent) over the same interval in favor of R&D firms.

Panel B of Table II presents estimates from the Fama-French three-factor model in equation (1).[15] As hypothesized, the estimated intercepts from time-series regressions of the difference in return between firms with R&D and those without R&D (*RD* − *NORD*) on the three systematic factors are significantly positive when insiders purchased shares (0.011, $t = 2.40$), and significantly negative when insiders sold shares (−0.005, $t = -1.85$). The estimated intercepts are close to the univariate returns in Panel A: 0.0092 for purchases and −0.006 for sales. Given that the average interval over which these returns were gained was 25 days, the estimated gains are economically meaningful as well, particularly for stock purchasers.

An additional test is performed to gain insight into the association between R&D *intensity* and insider gains. First, we divide the sample into three groups: Firms without R&D expenditures, firms with R&D intensity (R&D over sales) below the sample median (low R&D), and firms with R&D intensity above the sample median (high R&D). We then run the three-factor model in equation (1) for return differences between Low and No-R&D, High and No-R&D, and High and Low R&D portfolios. These regressions are run separately for net purchasers and net sellers of shares. Following are the estimated α coefficients and t-values from these regressions:

A. Insider Purchases	α coefficient	t-value
Low R&D minus No-R&D	0.002	0.388
High R&D minus No-R&D	0.021	3.446
High R&D minus Low R&D	0.019	2.997
B. Insider Sales	**α coefficient**	**t-value**
Low R&D minus No-R&D	−0.004	−1.643
High R&D minus No-R&D	−0.006	−1.783
High R& D minus Low R&D	−0.002	−0.510

The estimated α coefficients indicate that for insider purchases of shares, the differential gain between R&D and No-R&D firms is mainly due to *high* R&D-intensity firms, as indicated by the estimated α for High R&D minus No-R&D (0.021), which is 10 times larger than the estimated α of Low R&D minus No-R&D (0.002). For insider sales, the increase in insider gains in R&D firms (relative to No-R&D) is more monotonic in R&D intensity, as indicated by an estimated α of −0.004 for Low R&D minus No-R&D and α of −0.006 for High R&D minus No-R&D firms.

[14] Such an investment strategy cannot, of course, be implemented by outsiders who are not informed about insiders' transactions in real time.

[15] We obtain similar results with a four-factor model, where the fourth factor is a return momentum (see, Carhart (1997)).

The analysis reported in this section thus indicates that insiders in R&D firms gain from trade in their firms' shares significantly more than insiders in No-R&D firms, and that for share purchases the gain differential is mainly attributed to firms with high (above median) R&D intensity.

IV. Investors' Reaction to the Disclosure of Insider Trades

Section 16(a) of the 1934 Securities Act requires insiders to report their preceding month's trade to the SEC no later than the tenth day of each month. An examination of investors' reaction to the *public disclosure* of insiders' trades offers an opportunity to investigate several important issues. In particular:

(1) Is R&D a significant driver (cause) of information asymmetry? If, as hypothesized above, R&D contributes to information asymmetry, it is reasonable to expect investors to react more strongly to the disclosure of insider trades in R&D firms than in No-R&D firms. The reason: Given the relative scarcity of public information about firms' research and product development activities, insider trades in R&D companies convey, on average, more information to the market than insider trades in No-R&D firms.

(2) Is insiders' private information fully and quickly revealed to investors by financial analysts' search efforts and by insiders' own trade activities? In case of such an efficient information revelation, there should be no unusual investor reaction to the public disclosure of insiders' trades. If, however, insiders' private information is not fully revealed to the market (thereby creating gain opportunities), the public disclosure of their trade should trigger investor reaction.

Our test results (below) indicate that R&D activities do contribute to information asymmetry and that not all of insiders' private information is revealed before the public disclosure of their trades. Table III presents raw returns for three disclosure intervals: The day the trade information was filed with the SEC (day 0);[16] the cumulative return over the day of filing and the subsequent trading day (0, +1); and the three-day cumulative return beginning with the day of filing (0, +1, +2). We include days +1 and +2 in the analysis because the SEC may disclose insiders' filings after trading hours of day 0 or on the following day. As reported in Table III, for each of the three disclosure intervals the mean returns are positive when insider purchases were disclosed and negative when insider sales were disclosed, for both R&D and No-R&D firms. Thus, consistent with Kyle (1985, 1989), despite analysts' search activities and insiders' own trade, not all of insiders' private information is revealed to investors prior to trade disclosure. However, the reaction to disclosure of insider trades in R&D firms is significantly stronger than the reaction to firms without R&D. When insiders'

[16] This date is defined in our database as the date when the filing was received by the SEC.

Table III

Investors' Reaction to the Disclosure of Insider Trades

Day 0 is the date when the filing on insider transactions was received by the SEC. Days (0, +1) refers to the cumulative raw return over day 0 and the following trading day. Days (0, +1, +2) is the three-day return. There are 29,689 sale transactions for No-R&D firms and 24,166 sale transactions for firms with R&D. There are 24,961 purchase transactions for No-R&D firms and 9,262 purchase transactions for R&D firms. The total number of insider transactions here is smaller than in Table I, because multiple transactions per firm reported to the SEC on the same day are considered here as one transaction. All mean and median returns are significantly different from zero at the one percent level. # > 0 indicates the percentage of individual returns that are positive.

	Insider Purchases			Insider Sales		
	Mean	Median	# > 0	Mean	Median	# > 0
Day 0						
Firms without R&D	0.15%***	0.00%*	35.6%	−0.10%*	0.00%***	39.3%
Firms with R&D	0.31%***	0.01%*	55.5%	−0.15%*	−0.01***	38.4%
Days (0, +1)						
Firms without R&D	0.24%***	0.00%*	44.3%	−0.19%***	0.00%***	45.1%
Firms with R&D	0.40%***	0.01%*	55.1%	−0.34%***	−0.01%***	44.4%
Days (0, +1, +2)						
Firms without R&D	0.39%***	0.00%*	47.7%	−0.28%***	0.00%***	46.9%
Firms with R&D	0.58%***	0.02%*	58.8%	−0.47%***	−0.01%***	42.2%

* and *** denote that the means or medians of the R&D and No-R&D firms are significantly different at the 10 and 1 percent levels, respectively.

purchase of shares were disclosed, the mean market reaction on day 0 for R&D firms was 0.31 percent versus 0.15 percent for No-R&D firms (the difference is significant at the 1 percent level). When insiders' sale of shares were disclosed, the mean market reaction on day 0 for R&D firms was −0.15 percent versus −0.10 percent for No-R&D firms.[17] The reaction to insider trade disclosure increases with the interval length, indicating that not all of the filed information is disclosed to investors on the filing date.[18]

The *volume* of trade surrounding the disclosure of insider transactions is another indication of information revelation. We find that for R&D firms where insiders sold shares the mean (median) volume of shares traded (deflated by outstanding shares) on day 0 was 0.74 percent (0.34 percent), whereas for No-R&D firms the mean (median) volumes were 0.41 percent (0.19 percent). The differences between those means (medians) are statistically sig-

[17] Repeating the analysis of Table III using value-weighted mean returns slightly increases the significance of the results, whereas using size-adjusted returns slightly decreases the significance of the results.

[18] We also calculate the correlation between the firms' R&D intensity (R&D to sales), as a proxy for information asymmetry, and the market reaction to trade disclosure on day 0. The correlation is 0.039 (p-value of 0.001) for insider purchases and −0.019 (p-value of 0.001) for insider sales.

nificant at the 1 percent level. For insider purchases in R&D firms, the mean (median) volume of shares traded (deflated by outstanding shares) on day 0 were 0.44 percent (0.28 percent), whereas for No-R&D firms, the mean (median) volumes were 0.25 percent (0.10 percent). The differences between those means (medians) are also statistically significant at the one percent level. We document similar, yet larger differences in volume of trade between R&D and No-R&D firms as we expand the interval to one and two days following the SEC filing date.

Based on the evidence, we conclude that investors react more strongly to the public disclosure of insider trades in R&D firms compared with firms without R&D activities, consistent with the hypothesis that R&D contributes to information asymmetry. Stated differently, there is more private information in R&D companies than in companies without R&D and observing insider trades (even with a time lag) is one means of narrowing the information gap. Furthermore, investors' significant reaction to insider trade disclosure, made on average 25 days after the actual trade, indicates that not all of insiders' private information is revealed through their own trade or analysts' search activities.

V. Robustness Tests

A. Trade Intensity and R&D

If R&D enhances information asymmetry and managers exploit this asymmetry we would expect heavier insider trade activity in R&D firms than in firms without R&D, as the formers' officers attempt to gain from unique private information. The heavier activity of insiders in R&D firms may be reflected in more *frequent* trade and/or more *intensive* trade (relative to shares outstanding). Indeed we find that insiders in R&D firms trade relatively frequently: The mean (median) number of insider trades for R&D firms over the sample period was 17.1 (11) per firm, compared with 15.3 (9) for No-R&D firms.[19] We also find that the intensity of insider trades, measured in various ways, is higher for R&D firms than for firms without R&D. For example, when we measure trade intensity by the ratio of the number of shares traded by insiders in each transaction to the firm's outstanding shares, we find the mean (median) of that ratio for R&D firms to be 0.07 percent (0.03 percent), whereas for firms without R&D it is 0.06 percent (0.02 percent); the differences for both mean and median are statistically significant at the one percent level. Furthermore, the correlation between R&D intensity and insider trade intensity is 0.112 (p-value of 0.0001). When insider trade intensity is measured as the ratio of the number of shares traded by an insider to the individual's total share holdings, we find the mean (median) intensity in R&D firms to be 22.4 percent (8.5 percent) versus 21.5 per-

[19] The means and medians mentioned here are significantly different at the one percent level between R&D and No-R&D firms.

cent (6.5 percent) in No-R&D firms (the differences are once more significant at the one percent level). The correlation between this intensity measure and the firm's R&D intensity is 0.066, significant at the 1 percent level.[20]

The heavier trade activity of insiders in R&D firms documented here raises the question whether our findings in Section III (R&D officers gain more from inside trading than their counterparts in No-R&D firms) are due to trade intensity differences, rather than to information asymmetry. To examine this question we construct a sample of insider trades matched by trade size and run the three-factor regressions (1) on this sample. Specifically, for each sample month (1985–1997) we rank the *combined* R&D and No-R&D samples (separately for stock purchases and sales) by dollar value of transaction, and select adjacent R&D and No-R&D trades, where the difference in trade value was smaller than 10 percent. These pairs of value-matched transactions are inputs into the three-factor regression.[21]

The regression estimates of these size-controlled insider transactions are somewhat stronger than those in Panel B of Table II. The intercept estimate for insider purchases is 0.011 ($t = 2.00$), nearly identical to the α estimate in Table II, and the intercept estimate for insider sales is -0.007, $t = -2.27$ (compared with -0.005, $t = -1.85$ in Table II). We conclude, therefore, that the difference in insider gains between R&D and No-R&D firms is not induced by differences in size (value) of trades; rather managers of R&D firms exploit the relatively large information asymmetry associated with R&D.

B. Insider Gains and Changes in R&D Expenditures

Research indicates that changes in firms' R&D expenditures, once disclosed, are positively associated with stock returns (e.g., Chan, Kesinger, and Martin (1992), Lev and Sougiannis (1996), and Aboody and Lev (1998)). Insiders, aware of changes in R&D budgets ahead of investors, are therefore expected to act on such information, increasing share purchases prior to disclosure of R&D increases and selling more than usual ahead of disclosure of R&D decreases. This conjecture is examined here.

Firm-specific changes in R&D expenditures are computed as the percentage change in a given quarter's R&D relative to R&D expenditures in the preceding quarter (there is no seasonality in quarterly R&D expenditures and therefore adjacent quarters are used in the change computation). During the sample period (1985–1997), quarterly R&D expenditures increased (decreased) in 63.1 percent (36.9 percent) of the sample cases. Because many

[20] We also find that the mean (median) number of shares traded in each insider transaction was 7,102 (4,000) shares for firms with R&D activities and 5,693 shares (2,000 shares) for firms without R&D expenditures. Similarly, the value of shares traded was significantly higher for firms with R&D than for No-R&D firms: The mean (median) value of shares traded in each transaction was $164,764 ($50,000) for firms with R&D versus $140,399 ($24,200) for firms without R&D expenditures. Moreover, the number and value of trades is higher in R&D firms than in No-R&D firms for *both* sale and purchase transactions.

[21] The value match was close: The mean (median) transaction value is $215,648 ($48,000) for R&D firms and $214,526 ($47,787) for No-R&D firms.

of the quarterly R&D changes are rather small (R&D time series are generally stable), we rank the firm-specific R&D changes by size and focus the analysis on the upper (relatively large R&D increases) and lower (large R&D decreases) quartiles.

For firms in the upper quartile of R&D changes, insiders purchased over the sample period a total of 40.0 million shares and sold a total of 91.4 million shares ahead of the disclosure of R&D increases in quarterly reports.[22] This purchase-to-sales ratio of 0.44 is substantially larger than the overall sample purchase-to-sales ratio (Table I) for R&D companies—0.26 (312 to 1,187 million shares)—suggesting enhanced insider purchases prior to an R&D increase announcement. For the bottom quartile of firms ranked by R&D changes (relatively large R&D decreases), insiders purchased 9.6 million shares and sold 138.9 million shares ahead of the quarterly report. The ratio of purchase-to-sales ahead of R&D decreases—0.07—is substantially smaller than the sample mean (0.26). It appears, therefore, that insiders increase share purchases ahead of disclosing R&D increases and enhance the sale of shares ahead of R&D decreases.[23]

We also perform a portfolio analysis conditional on the direction of R&D changes. Specifically, we form calendar-time portfolios for each sample month (1985–1997, 155 months in total) of firms that have experienced an increase in R&D and those whose R&D has decreased. We do this separately for firms where insiders were predominantly purchasing shares during the month (RDP_t) and firms in which insiders were predominantly sellers of shares (RDS_t). For each firm, an average return (over all insider transactions during the month) is computed from the date of an insider transaction to one day prior to filing with the SEC, similarly to the returns analyzed in Table II. The Fama-French three-factor model is used to estimate excess returns (α), where the dependent variable is the difference between returns from share purchases and returns from the sale of shares ($RDP_t - RDS_t$), for firms that *increased* R&D expenditures (i.e., going long on firms in which insiders were net purchasers and short on firms in which insiders were net sellers). For firms that have *decreased* R&D, the dependent variable is the difference between returns from insider sales minus returns from insider purchases ($RDS_t - RDP_t$).

Panel B of Table IV presents estimates of the three-factor model, conditional on foreknowledge (prior to public disclosure) of the change in R&D expenditures. It is evident from the α coefficients that for R&D *increases* (top row of Panel B), going long on firms in which insiders were net pur-

[22] The computation of shares purchased and sold by insiders is made for every fiscal quarter t, in 1985–1997. The public disclosure of the change in R&D expenditures in quarter t, relative to $t - 1$, was made in quarter t financial report, released in quarter $t + 1$.

[23] The mean (median) number of shares per insider transaction is also consistent with the direction of R&D changes. For R&D *increases*, the mean (median) number of shares in purchase transactions were 17,019 (5,000) versus 15,912 (2,500) for sale transactions. For R&D *decreases*, the mean (median) number of shares in purchase transactions were 10,003 (1,000) versus 29,000 (15,000) for sale transactions.

Table IV

Returns Earned on Portfolios Formed on the Basis of Changes in R&D Expenditures

Panel A presents percentage raw returns earned on portfolios formed as follows: For each month between January 1985 and November 1997 we calculate, for each firm engaged in R&D, the raw return for each insider transaction from the transaction date to one day prior to the SEC filing date. We then calculate firm-specific mean (median) returns for firms in which insiders were net purchasers and for firms in which insiders were net sellers of shares. We compute returns separately for firms that increased R&D and those that decreased R&D expenditures. These mean (median) returns are reported in Panel A. # > 0 refers to number of months (out of 155) in which returns were positive. In Panel B, the estimated coefficients of the three-factor Fama-French regressions are presented. The dependent variable for R&D increases is the difference in excess returns (over the interval between transaction and filing date) between a portfolio of firms in which insiders were net purchasers of shares (RDP_t) and a portfolio of firms in which insiders were net sellers of shares (RDS_t). For R&D decreases, the dependent variable is reversed: $RDS_t - RDP_t$.

Panel A: Univariate Returns

	Insider Purchases			Insider Sales		
	Mean	Median	# > 0	Mean	Median	# > 0
Increase in R&D	5.55%***	4.74%***	129	1.53%***	1.37%***	98
Decrease in R&D	0.88%***	0.70%*	88	−1.28%***	−0.60%***	68

Panel B: Three-factor Model

	α	$RM_t - RF_t$	SMB_t	HML_t	Adjusted R^2
R&D increases					
$RDP_t - RDS_t$	0.042***	−0.211	0.135	0.023	0.006
t-statistic	(8.33)	(−1.59)	(0.70)	(0.09)	
R&D decreases					
$RDS_t - RDP_t$	−0.022***	0.053	0.034	0.034	0.001
t-statistic	(−5.23)	(0.48)	(0.21)	(0.17)	

* and *** denotes significance at the 10 and 1 percent levels, respectively.

chasers of shares and short on firms where insiders were net sellers yielded an excess return of 4.2 percent over an average of 25 days between transaction and SEC filing date. For firms that have *decreased* R&D, the opposite strategy would have yielded an excess return of 2.2 percent. Both excess returns are highly statistically significant.

Note that the estimated excess returns (α) in Table IV (4.2 percent and −2.2 percent) are substantially larger than those in Table II (1.1 percent and −0.5 percent), indicating extra gains obtained by insiders possessing inside information about future *changes* in R&D budgets, relative to the gains based on the "average information" possessed by insiders.

Finally, Panel A of Table IV presents mean (median) returns to insider trading in the expected direction (e.g., purchasing during an R&D increase), as well as to "contrarians"—insiders that purchased shares ahead of an R&D

decrease announcement and those that sold shares ahead of an R&D increase. The contrarians' mean gain from purchasing shares during a period of an R&D decrease (0.88 percent) is substantially lower than that of insiders who purchased during R&D increases (mean return of 5.55 percent). The contrarians who sold shares during R&D increases saw share prices gain 1.53 percent, on average, after they sold their shares. We can only speculate that those contrarians were motivated by liquidity or portfolio diversification needs.

VI. Concluding Remarks

We examine insiders' gain from trade focusing on a specific source of information asymmetry—firms' R&D activities. R&D is unique (firm-specific) relative to other forms of capital. It is not traded in organized markets and disclosure in corporate reports about the productivity and value of R&D activities is deficient relative to the disclosure of tangible and financial assets. Accordingly, we hypothesize, R&D activities contribute to the information asymmetry between managers and investors, and the former will tend to exploit this asymmetry to gain from insider trade.

We corroborate the hypothesis by providing evidence that insider gains in R&D-intensive companies are significantly larger than insider gains in firms not engaged in R&D. The R&D-related gains are both statistically and economically meaningful. We also find that investors' reaction to the public disclosure of insider trades is significantly stronger for R&D companies than for No-R&D companies, implying a larger information asymmetry in R&D firms, and that the R&D-related private information is not fully revealed prior to the public disclosure of insiders' trade. Finally, we report that insiders appear to time their transactions according to the direction of change in R&D expenditures, which is known to trigger investor reaction upon disclosure.

In this study we do not join the debate about the social consequences of insider trading. Some consider insider trading beneficial to market efficiency, and the loss to outside investors negligible, given the large volume differences between inside and outside investors (Jeng et al. (1999)). Others, including Congress and the SEC (which have, over the last six decades, constructed an elaborate system of civil and criminal laws designed to restrict insider trading and the consequent profits), are obviously concerned with the consequences of insider trading. Such concerns extend beyond the direct loss to outside investors, to include, for example, adverse effects on managers' incentives (e.g., Fried (1998)). For those concerned with the consequences of insider gains, our study points at an important and fast-increasing source of private information leading to such gains—firms' R&D activities. Improved disclosure about R&D operations, such as the capitalization of development costs when products successfully pass technological feasibility tests (e.g., Aboody and Lev (1998) for software companies) and the timely release of information about planned changes in R&D expenditures may be considered as means for mitigating the R&D-related information asymmetry and the consequent insider gains.

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