Product Diversification In Competitive R&D-Intensive Firms: An Empirical Study Of The Computer Software Industry

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ABSTRACT

This paper studies the effect of diversification into different product categories within competitive high-tech industries. Empirical results obtained using the prepackaged computer software industry as the sample show that: (1) diversified firms appear to be more profitable (have higher returns on equity), attain a larger market share, enjoy higher excess market returns, and have a higher market-to-book ratio; (2) from the investors' perspective, diversification per se does not increase firm value. Realized higher values do not appear to come from more efficient use of assets. Rather, they stem from the higher innovation efficiency (higher sales revenue per employee) and higher levels of R&D spending for firms that have diversified into different product categories than for firms that confine development to a single product category.

Keywords: R&D, Product Diversification, Computer Software Industry

INTRODUCTION

Diversification has intrigued the business world and researchers for decades. It is often used strategically to improve firm performance and/or to reduce risk. There are a number of different forms that diversification may take. Firms may diversify internally or through mergers and acquisitions, and they may diversify into related industries or un-related industries, into different geographical areas, and into different product categories within the same industry. In this paper, my focus is particularly on diversification by expansion into different product categories within a technology-intensive industry. I first examine empirically whether firms that diversify into different product categories perform better than un-diversified firms. I then investigate the potential source of the observed performance improvement and consider whether investors attach a higher firm value to diversified firms due to diversification alone, because of more efficient use of assets, or because R&D spending is valued more highly for diversified firms than for un-diversified firms.

I use the prepackaged computer software industry as the sample to conduct the empirical tests because (1) R&D is a critical factor for a computer software company's success; (2) the software market is known for its great diversity of product offerings; and (3) product-level data is commercially available. Unlike a cross-sectional study, an industry-specific study provides natural control for the external competitive environment (Sherer and Ross 1990) and for the technological conditions of the sample firms (Matolcsy and Wyatt 2008), both of which are hypothesized to affect firm performance. My empirical results show that (1) diversified firms have higher sales revenue per employee and higher returns on equity, attain a larger market share, and enjoy higher excess stock returns above S&P market returns; (2) diversified firms have a higher market-to-book ratio; (3) the superior performance of these firms is not explained by more efficient use of assets, as their average assets turnover rate is not better than that for undiversified firms; and (4) diversification per se does not add firm value, with R&D assets being valued more highly for firms that engage in multiple-product categories development than for firms that confine development to a single-product category.

The next section summarizes relevant prior research. I then present the pertinent hypotheses and outline the institutional setting of the computer software industry, followed by research design. Sample selection and summary statistics are reported and the empirical results and their implications are discussed. The final section provides a summary and conclusions.

PRIOR RESEARCH

Research on diversification can be roughly divided into the following threads. One thread centers on identifying the motives for diversification. For example, it has been argued that firms diversify to reap benefits from economies of scale by sharing resources, to increase market power, to prolong firm life, to reduce risk of bankruptcy, and to take advantage of tax shields (see Copeland, Weston, and Shastri 2004 for a survey of the relevant literature).

Another thread seeks to expose the firm-value dynamics created by different kinds of diversification. The extant literature indicates that firm value is reduced for diversification into unrelated industries, while diversification into related industries increases value (Berger and Ofeck 1995; Graham, Lemmon, and Wolf 2002), and that while geographic diversification adds firm value, industrial diversification decreases it (Bodner, Tang, and Weintrop 1998).

A related line of research investigates the effects of diversification on firm performance. The results obtained to date are inconclusive. For instance, using Rumelt's "Specialization Ratio" to define degree of diversification, Pandya and Rao (1998) find that, although diversified firms perform better in both risk and return dimensions than do undiversified firms, dominant undiversified firms as a group have higher average returns on equity that are accompanied by higher variance when compared to diversified firms. Stern and Henderson (2004) find that firms' failure rates increase (decrease) with primary-product line diversification when the external environment is (is not) very competitive.

Other than the Stern and Henderson study, most of the extant literature analyzes the impact of cross-industry diversification or cross-country diversification rather than that of the cross-product diversification within the same industry that is the focus of the present study. In both cross-industry and cross-country diversification, it is difficult to discern how long it takes for the diversification to have an impact on firm performance. Consequently, researchers are often left to assume an immediate effect and use mismatched performance measures in their studies. This renders the resulting implications invalid. In a market where technology advances rapidly, cross-product-category diversification has a direct and immediate impact on firm performance and market valuation. Therefore, the association between diversification and firm performance can be identified with greater accuracy.

HYPOTHESES DEVELOPMENT AND THE SOFTWARE INDUSTRY

In this section, I develop hypotheses that are pertinent to cross-product line diversification in competitive technology-intensive industries. Given this context for the hypotheses, I first review the market structure of one such industry that can represent these industries as a whole, namely the prepackaged computer software industry (SIC = 7372).

This is an industry that has experienced rapid growth from its 24 firms in 1979 to 445 in 1997. Its financial importance has also increased rapidly, with the market value of the average company growing from $80.83 million in 1979 to $1.587 billion in 1998.

The industry is intensively competitive, with the market share of an average firm being limited to about one per cent.[1] Software developers compete with their peers on price, product functions, speed, compatibility, and ease of use, as well as through other product qualities. What makes the competitive environment even more challenging is that technological advances affecting computer hardware may change the competitive environment virtually overnight.[2] In addition, it is a market for differentiated products, with competing firms producing a number of similar but not identical software items. Consumers in this market are aware of product differentiation and have varied preferences. To ensure that their needs and preferences are met in a timely manner and that the relevant product differentiation is recognizable, firms must make huge investments in marketing surveys and advertising campaigns. For these reasons, software products have relatively short economic lives. Consequently, patenting does not provide an effective means of deterring entry into this industry or of maintaining competitiveness. Instead, hiring and keeping skilled workers to ensure frequent innovations and upgrades, as well as sustaining product differentiation, are all critical for a software firm's survival and success.

Liebowitz and Margolis (1999) attribute the software market's unique structure to the following two characteristics: (1) instant scalability and (2) independence of product quality and marginal cost. Instant scalability refers to the fact that as the reproduction of a software product requires no more than a disk/CD-ROM duplicator, output can be expanded almost instantly. Independence of product quality and marginal cost refers to the fact that incorporating additional features into a software product often requires only transporting/altering program codes from another existing product. Improving a product's quality therefore adds little to its cost.

In searching for the types of resources that can be most successfully transferred in the process of diversification, Mata, Fuerst, and Barney (1995) identify those that are valuable, rare, and imperfectly mobile across firms, most especially technological knowledge. Such resource shifts can lead a firm to a position of both short-term and sustained competitive advantage.

The currently extant literature confirms that product diversity can be attained with little marginal cost, that product output is instantly scalable in competitive high-technological industries, and that the shared resources are both valuable, heterogeneous, and not easily mobilized in a cross-sectional manner. It follows that firms in such industries can take advantage of diversification by growing into other product categories within the same industry so as to achieve performance levels that are superior to those that can be realized by remaining undiversified. In reality, observations also indicate that firms that eventually enjoy large market shares are not necessarily the original creators of a product/product idea, but rather those that can develop products with the best designs at lower cost.[3] Hence, the following hypothesis is pertinent in the present context:

Hypothesis 1: Firms that diversify into different product categories within the same industry have superior profitability and a higher market valuation than those that do not diversify.

Although firms that have diversified into different product categories may enjoy superior profitability and a higher market valuation, diversification per se may not necessarily be the exclusive source of these outcomes. Two other factors may contribute to the extent of firm value increases associated with diversification in technology-intensive industries: (1) more efficient use of tangible assets and (2) higher innovation efficiency.

Improved performance may be achieved by diversification if a diversified firm can take advantage of economies of scale through the deployment of its combined tangible assets. However, efficient use of assets also relies on the political environment and the effectiveness of the internal organizational structure. For example, ROI-based compensation for divisional managers in a diversified firm is likely to result in myopic managerial behaviors and inefficient use of combined assets and resources. Because the political and internal organizational structure are highly idiosyncratic and firm-specific, the efficiency with which each firm uses its assets is likely to exhibit great variability. Therefore, it cannot be expected that any firm group will exhibit improved efficiency in assets use due to diversification alone.

For technologically-intensive firms, diversification may have a positive effect on firm value via improved innovation efficiency. Teece (1980) contends that R&D divisions can share their technological innovations, taking advantage of economies of scale in the innovation effort and thereby achieving higher innovation efficiency. In the case of software development, a technological advance in one area can significantly benefit development in other areas. For instance, advancement in the object-oriented paradigm has been applied in the development of many software products such as databases, word processors, and web browsers. If innovation efficiency can be achieved across products and divisions, investments in R&D will be valued more for a diversified firm than for a non-diversified firm. Here the following hypothesis becomes relevant:

Hypothesis 2: R&D spending is more valuable for firms that diversify into different product categories (within the same industry) than for those that do not diversify.

RESEARCH DESIGN

Operational Measures

Level of Diversification. The modified Herfindahl Index in Holthausen et al. (1995) is applied to measuring the *level of diversification*, with diversification in the present study measured across product categories as follows. Each software product in the sample is classified (by PC Data) into one of six categories: business, education, finance, games, personal productivity, and reference software. The total sales amount for each product category of each firm is first summed and then squared. The sum of the squares for each category is then divided by the squared total of firm sales to form the firm's modified Herfindahl index. With six categories under consideration, the modified Herfindahl index should fall between 0.167 and 1 (inclusive). A score of 1 indicates a firm's non-diversification status. The closer a score is to 0.167, the more diversified the firm is. The Herfindahl index is ultimately converted to a dichotomous measure, with diversified firms (score <1) taking D=1 and the non-diversified group (score=1) taking D=0 or into three groups.

Other performance measures. *Return on Equity* is net income divided by common equity value. It measures the amount of net income earned by common shareholders for each dollar of investment. *Assets Turnover* is calculated by dividing net sales by total assets. It measures how efficiently assets are used to produce sales. The *Gross Margin Ratio* is gross profit (net sales minus cost of sales) divided by net sales. Higher gross margin ratios indicate lower costs per dollar of sales. *Market Share* is the sum across 12 months of sales provided by PC Data divided by the total industry sales. *Excess Market Returns* is measured as the stock price appreciation of a given year minus the S&P-500 returns for that year. It provides the investors' perspective of firm value and may incorporate forward-looking information beyond the historical information presented in accounting reports. The *Market-to-Book Ratio* is the market price of equity divided by the book value of equity. It is hypothesized to measure, inter alia, risk, market strength, and growth potential.

To test hypothesis 2 on the heterogeneity of cross-sectional market valuation of R&D, the following returns regression model applies:

$$R_i = \gamma_0 + \gamma_1(RD_i) + \gamma_2(\Delta RD_i) + \gamma_3(D_i) + \gamma_4(D_i)(\Delta RD\ ) + \gamma_5(\Delta E_i) + \gamma_6(\Delta E_i)(D_i) + \gamma_7(E_i) + \gamma_8(SIZE_i) + \varepsilon_i$$

Where

R_{it}	is the annual common stock return per share, accumulated beginning nine months before to three months after the fiscal year end;
RD_{it}	is the R&D expenditure for firm i in year t; in this study it includes R&D expense and capitalized R&D;
$\Delta\ RD_{it}$	is the change in annual R&D spending per share;
E_{it}	is the annual earnings per share before R&D for firm i;
ΔE_{it}	is the change in earnings per share before R&D for firm i in year t;
$SIZE_{it}$	is the natural log of the market value of equity.

All variables except the intercept, R_{it}, and $SIZE$ are scaled by the market value at time t-1.

D = 1 for diversified firms; D = 0 for non-diversified group.

In the above model, the group that is assigned D = 0 is the base group. A significantly nonzero γ_3 shows how much the group with the characteristic D = 1 differs in its average annual stock returns from the base group after controlling for other factors.[4] A significantly nonzero γ_4 would validate the heterogeneity hypothesis. For the hypothesis relating to product diversification, a significantly positive γ_4 would indicate that R&D is valued more for diversified firms than for non-diversified firms. A prediction for γ_2 is not available because the sign of γ_2 should be considered along with the sign of γ_4. A positive γ_1 would suggest that R&D spending is priced as for assets in general. However, if γ_2 is non-positive but γ_4 is positive, it would suggest that incremental R&D spending is priced as for assets only in the case of diversified companies.

The other predictions are that γ_5, γ_6, γ_7, the coefficients of earnings change, the interaction between earnings change and the dummy, and earnings level, respectively, are indeterminate. The reasons for these results are discussed below.

Several returns-earnings relationship studies (for example, those of Easton and Harris 1991 and of Ali and Zarowin 1992) have shown that both the current earnings level and the earnings change variables are positively associated with stock returns. Aboody and Lev (1998) decompose net income into R&D components and net income before R&D and still find a significantly positive association between the stock returns and the net income before R&D in the pooled regression. However, Black (1998) argues that earnings are not value-relevant for start-up and growth firms because earnings persistence is lower for these firms and a large portion of their value consists of their growth opportunities. His empirical findings are consistent with his prediction in showing that earnings of start-up and growth firms are not positively correlated with market value. Hayn (1995) finds that reported losses are less informative concerning a firm's future prospects and exhibit a weaker association with returns than with profits. Since the prepackaged computer software industry is relatively young, the expectation here is that the majority of sample firms will be in the start-up and growth stages. I also expect the sample firms to report more losses than do firms in more mature industries. If the earnings effect of start-up and growth firms and/or the effect of losses dominate, γ_5 and γ_6 may not be positive in equation (3). Thus, no sign is assigned to the prediction for earnings. In addition, two separate regressions will be conducted for the loss group and for the profit group in order to control for losses.

The extant literature reveals that larger firms have smaller earnings response coefficients than smaller firms. In the R&D context, it is argued that centralization is necessary for large firms to control employee managers and that a more centralized firms tend to inhibit innovation due to their more bureaucratic control mechanisms (Holthausen et al. 1995). To the extent that firm size is a proxy for centralization, firm size could show a negative correlation with the market valuation of R&D spending. However, as firm size is also related to the availability of financial resources, then if such availability can facilitate innovation efficiency, firm size will be positively correlated with the market valuation of R&D. Since the size effect on the market valuation of R&D investment is ambiguous, but the effect of size on firm valuation is well documented, firm size is used only as a control variable in the present study.

In short, the predictions are: $\gamma_1 > 0$, $\gamma_4 > 0$.

DATA

Sample Selection

Sample selection set out from the firms listed as being in the computer software industry in "Yahoo! Finance" as of February 20, 1998. A firm in the final sample must satisfy the following selection criteria: (1) its SIC code is 7372 (prepackaged computer software industry), (2) its relevant data for the fiscal years 1993 to 1998 must be available in the 1998 COMPUSTAT file and the 1998 CRSP daily and monthly files, (3) data about its monthly sales of each retail software product for the years 1994 to 1997 must be available from the PC Data Retail Sales Report,[5] and (4) its number of employees must be available through its 10-K reports. The final sample consists of 176 firm-year observations across 44 software developers during the years from 1994 to1997.

Summary Statistics

The summary statistics for the software firms used in testing are provided in Table 1. Two sample statistics reveal the importance of R&D in the prepackaged computer software industry: (1) on average, three out of every ten employees in these companies worked in the software development division, and (2) the average firm in the sample spends 28% of its net sales on R&D (a measure of R&D intensity). The R&D intensity ranges from less than 1% to more than 300%. The average firm increases annual R&D spending by $23.6 million during the sample period. The annual operating income of the sample firms ranged from a loss of $64 million to a profit of $7.468 billion. Market capitalization of the firms ranged from $6.588 million to $273.837 billion, with a median of $309 million. Except for Computer Associates, which was traded on the New York Stock Exchange, all other firms were traded on the National Association of Securities Dealers Automated Quotation System (NASDAQ) during the sample period.

Table 1: Summary statistics for the software firms used in empirical testing
For the Years 1993 to1998
(in thousands of dollars except for percentages)

	N*	Mean	Median	Std. Dev.	Minimum	Maximum
Total Assets	206	732,622	86,790	2,332,000	601	22,357,000
Market Value of Common Equity	217	4,757,098	309,399	23,038,895	6,588	273,836,744
Operating Income	204	199,854	10,749	798,171	-64,467	7,468,000
R&D Spending	197	103,642	20,033	295,527	342	2,502,000
Change in R&D Spending	173	23,608	4,983	135,921	-672,680	1,085,000
R&D Intensity (=R&D Spending/ Sales)	197	28.41%	19.09%	35.50%	0.09%	302.17%
% of technical employees (1994-1998)**	84	31.62%	30.61%	13.74%	9.62%	75.68%
Annual Stock Returns	182	49.72%	16.67%	143.93%	-85.63%	1,047.6%

*Expanded samples are used when data is available.
**Percentage of technical employees based on an expanded sample of 386 observations ranges from 4% to 90.9%, with a median of 28% and an average of 31%.

The sample statistics for the market structure variables are presented in Table 2. Evidence of dissimilar market shares and market domination are clearly present. Between 1994 and 1997, the aggregate market share of the sample firms ranges from less than 0.001% to 22%, with a mean of 1.33% and a median of 0.15%. Only one firm has an aggregated market share of more than 10%. As expected, Microsoft is this dominant software developer and has a market share (22% in 1994) that dwarfs that of the other players in the retail market for all four years tested.

The modified Herfindahl index measures the degree of diversification of a firm across different product categories. As discussed in Section IV above, the index should fall between 0.167 and 1 (inclusive). As shown in Table 2, the median of 1 suggests that more than 50% of the sample firms only produce items in one product category. The mean of 0.89 implies that most firms are not very well diversified among the six product categories defined by PC Data.

Table 2: Sample statistics for product market structure variables
Sample period: 1994 to 1997

Variable	N	Mean	Median	Std. Dev.	Min.	Max.
Aggregate Market Share	145	1.33%	0.15%	3.56%	<0.0001%	22.1%
Modified Herfindahl Index	145	0.891	1	0.204	0.282	1
Age of the Sample Firm's Average Product on the market since its first release (in months)	155	15.4	15.9	7.0	1	33
Ratio of New Products to Total Products on the Market	143	0.533	0.5	0.279	0	1

Aggregate Market Share of a firm is the firm's total sales divided by total industry sales.
Weighted Average Market Share of a firm is the sum of its market share in a product category multiplied by the percentage of its revenue derived from that product category.
Modified Herfindahl Index, used as a diversification measure in this study, is the sum of the squares of a firm's sales in each product category divided by the squares of its total sales.

Statistics on the software products' age and on the percentage of new products on the market reveal the speed of product innovation in the computer software sector. For the average firm, the products on the market have an average age of around 16 months. Where the average age is one month, this minimum indicates that either some new company has just rolled out its new products or some firm has just entered the retail market. No firm sells products that average more than three years old. The average firm has equal numbers of new products and old products on the market (50%) with more than 20 firm-year observations having 100% new products on the market.

RESULTS

The Wilcoxon Test was used to examine the difference between the firms' performances in the diversified and undiversified groups because normality tests results (not presented here) show that the sample is not normally distributed. The first three rows of Table 3 show that the diversified and undiversified groups do not differ, at least statistically, in terms of firm size as measured by net sales and total assets. They are also similar in terms of R&D investment per dollar of net sales. In terms of profitability, though, diversified firms enjoy a 5% greater return on equity than do undiversified firms. Diversified firms also acquire more than 120 times the market share of that available to undiversified firms and deliver 30% more in excess market returns than do undiversified firms. The market-to-book ratio is higher for diversified firms than for the undiversified group as well. However, the gross margin ratio of the undiversified group is 20 points higher than for diversified firms, suggesting that firms in the single-product category achieve relatively lower costs of sales, perhaps due to the expertise they developed in the specific product categories. The differences between these two groups are all statistically significant at the 5% level, suggesting that firms that diversified into different product categories, although similar in size and R&D intensity, have higher profitability, a larger market share, and a higher market valuation than do undiversified firms.

Table 3: Wilcoxon two-sample test for equality of sample median

	Non-diversified (n=76)	**Diversified** (n=68)	**Wilcoxon statistic** (One-sided P-Value)
Sales	69.768	133.10	0.385
Assets	71.608	97.651	0.339
R&D Intensity	18.53%	19.06%	0.228
Sales per employee	0.1783	0.2921	<0.0001
Return on Equity	10.11%	15.73%	0.039
Gross Margin	84.50%	66.44%	<0.0001
Market Share	0.006	0.748	<0.0001
Excess Market Returns	-26.40%	15.93%	0.024
Market-to-Book	4.192	5.674	0.002
Assets Turnover	0.942	1.037	0.110

The asset turnover ratios, however, do not show any statistically significant difference between the diversified (1.037) and the undiversified groups (0.942), implying that the improved profitability and market valuation achieved by expanding into different product categories are not associated with efficiencies in using tangible assets.

Table 4 reports the results for the hypothesis relating to the market valuation of R&D expenditures using the returns regression. The hypothesis predicts that R&D spending is more valuable for a diversified firm than for a non-diversified firm. The coefficient of the interaction term of change in R&D expenditure and the diversification measure is 12.244, significant at the 10% level, which suggests that R&D expenditure contributes around 12% more to annual stock returns for diversified firms than for non-diversified firms. The coefficient of the R&D increment is not significant, implying that increases in R&D spending only add to firm value for diversified firms and not in the case of non-diversified firms.

Table 4: Product diversification and market valuation**

$$R_i = \gamma_0 + \gamma_1(RD_i) + \gamma_2(\Delta RD_i) + \gamma_3(D_i) + \gamma_4(D_i)(\Delta RD\ ) + \gamma_5(\Delta E_i) + \gamma_6(\Delta E_i)(D_i) + \gamma_7(E_i) + \gamma_8(SIZE_i) + \varepsilon_i$$

D_i = 1 for firms whose Herfindahl Index <1 (Diversified firms); n = 51

D_i = 0 for firms whose Herfindahl Index =1 (Non-diversified firms); n = 59

Variable	Predicted Sign	Parameter Estimate (P-value)*	Parameter Estimate (P-value)*
Intercept		-2.605 (0.042)	-3.150 (0.018)
RD	+	4.716 (0.063)	4.133 (0.058)
ΔRD		10.228 (0.004)	-0.005 (0.999)
D			0.496 (0.301)
$(\Delta RD)(D)$	+		12.244 (0.071)
ΔE		3.560 (0.008)	0.614 (0.897)
$(\Delta E)(D)$			3.320 (0.488)
E		-0.249 (0.909)	-0.870 (0.696)
$SIZE$		0.197 (0.036)	0.211 (0.024)
Adjusted R^2		25.4% (N = 110)	26.0% (N = 110)

* P-values reported are for the one-tailed test if there is a prediction and for the two-tailed test if no prediction is made.
**Because the diversification information used in this study is compiled on the basis of software developers' data for the retail market, the regression results reported here are weighted by percentages of sales derived from retail sales.

Notice that when the diversification dummy is included in the regression, both earnings level and earnings change do not show any statistical significance. Separate regressions for the loss group and the profit group (results not provided here) do not generate different (in terms of the significance of the parameters) results with respect to earnings. Only when the observations are equally weighted (that is, when regressions are not weighted by the percentage of retail sales) does the coefficient of earnings change become statistically significantly positive at below 3% levels. This result implies that in terms of market valuation, earnings surprises are not as important as product diversification for those firms with sales dominated by retail sales. For firms that depend less on retail sales, earnings changes are still value-relevant.

The results confirm that diversification alone does not increase firm value and that incremental R&D spending alone does not add to firm value unless the firm has a diversified product portfolio. R&D expenditure level is statistically significantly positive in all the returns regressions and its coefficient is around 4, suggesting that R&D is viewed as critical in the prepackaged computer software industry.

SUMMARY AND CONCLUSIONS

The paper studies same-industry diversification among firms within the prepackaged software industry. My key argument is that because of the ease of transferability of the knowledge developed in one product category to other product categories, firms that choose to diversify by expanding their product categories in the same industry can take advantage of economies of scale in innovation and achieve improved profitability and market valuations. Empirical tests demonstrate that diversified firms on average have higher returns on equity, higher sales per employee, higher market-to-book ratios, and higher market shares than do undiversified firms. However, better performance through diversification is not associated with the efficiency of employing tangible assets.

I further test the hypothesis in the regression model using accounting data, stock price, and an extensive database that contains retail sales information at a product level for the software firms between 1994 and 1997. Empirical evidence, consistent with my hypothesis, suggests that R&D is more valuable for firms that are developing products in different categories within the software industry than for undiversified firms. Test results are not sensitive to how the variables are measured.

AUTHOR INFORMATION

Dr. Catherine Chiang is an Assistant Professor of Accounting with Love School of Business at Elon University, an AACSB accredited school. She received her Ph.D. degree in Accounting from the City University of New York, the Master of Accounting degree from UNC-Chapel Hill and Master of Science in Management degree from NC State. Prior to joining Elon, she has taught at CUNY- Baruch College, Greensboro College, and North Carolina Central University. She has published articles in *Journal of Accounting and Public Policy, Review of Quantitative Finance and Accounting*, among others. Her research focuses on the capital market valuation of accounting numbers, especially the valuation of intangible assets such as R&D.

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ENDNOTES

[1] See Table 2.
[2] For instance, a software product designed to improve the running speed of a computer operating system might be rendered obsolete by a higher-speed computer chip.
[3] For example, the Graphic User Interface (GUI) computer operating system was an idea created in the Xerox laboratory to make operating systems user-friendly. Apple Computers adopted the GUI idea and applied it to its Macintosh Computers. Macintosh Computers' success in the consumer market in the 1980s can be largely attributed to its GUI operating system, the Macintosh OS. However, the OS that currently dominates the market for personal computers is Microsoft's Windows, even though it was introduced five years after the Macintosh OS.
[4] Because the dummy may also influence how the market prices earnings surprises, I add an interaction term of change in earnings and the dummy, $\Delta E * D$ in equation (4) to control for any effect the dummy may have on stock returns through earnings.
[5] PC Data was a market research company that collected monthly sales data from computer software wholesalers, distributors, and retailers across the United States. It was merged into the company currently known as Marketresearch.com. To compile its Retail Sales Report, PC Data asked the contracted software retailers to provide information about their monthly sales in units and in dollars for each software title. The market share of each product and the date of its first appearance were also collected in the report.