Longitudinal Study on the Performance of U.S. Pharmaceutical Firms: The Increasing Role of Marketing

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ABSTRACT AND KEYWORDS	
Abstract	Nowadays, the U.S. pharmaceutical industry has been under thorough scrutiny. Popular press claims of intensive marketing activities that go beyond R&D, the strong increase of me-too drugs, and, at the same time, the high industry profitability have contributed to public skepticism. Despite this increasing role of marketing, studies on the profitability of pharmaceutical firms mainly focus on the role of R&D. In this paper, we investigate the impact of advertising and product differentiation on pharmaceutical firms' market value over the period 1971-2005. Especially, we examine whether there has been a change in the pattern of returns in these variables over this period. Our results show that, nowadays, pharmaceutical firms' performance is not only closely linked to their R&D activities but also to marketing activities such as advertising and product differentiation. Since the 1990s, the return of advertising has become three times larger than that of R&D. In addition, we found that the impact of product differentiation came largely from the introduction of the so called incrementally modified drugs (IMD). The vast increase of the number of IMDs since the 1990s is likely to contribute to this development. Our results emphasize the role of advertising and product differentiation in the virtuous rent-seeking behavior in the pharmaceutical industry.
Free Keywords	Advertising, Product differentiation, Marketing, Market value, Panel data, Pharmaceutical industry
Availability	The ERIM Report Series is distributed through the following platforms: Academic Repository at Erasmus University (DEAR), DEAR ERIM Series Portal Social Science Research Network (SSRN), SSRN ERIM Series Webpage Research Papers in Economics (REPEC), REPEC ERIM Series Webpage
Classifications	The electronic versions of the papers in the ERIM report Series contain bibliographic metadata by the following classification systems: Library of Congress Classification, (LCC) LCC Webpage Journal of Economic Literature, (JEL), JEL Webpage ACM Computing Classification System CCS Webpage Inspec Classification scheme (ICS), ICS Webpage

LONGITUDINAL STUDY ON THE PERFORMANCE OF U.S. PHARMACEUTICAL FIRMS: THE INCREASING ROLE OF MARKETING

L.H. Pattikawa

ABSTRACT

Nowadays, the U.S. pharmaceutical industry has been under thorough scrutiny. Popular press claims of intensive marketing activities that go beyond R&D, the strong increase of me-too drugs, and, at the same time, the high industry profitability have contributed to public skepticism. Despite this increasing role of marketing, studies on the profitability of pharmaceutical firms mainly focus on the role of R&D. In this paper, we investigate the impact of advertising and product differentiation on pharmaceutical firms' market value over the period 1971-2005. Especially, we examine whether there has been a change in the pattern of returns in these variables over this period. Our results show that, nowadays, pharmaceutical firms' performance is not only closely linked to their R&D activities but also to marketing activities such as advertising and product differentiation. Since the 1990s, the return of advertising has become three times larger than that of R&D. In addition, we found that the impact of product differentiation came largely from the introduction of the so called incrementally modified drugs (IMD). The vast increase of the number of IMDs since the 1990s is likely to contribute to this development. Our results emphasize the role of advertising and product differentiation in the virtuous rent-seeking behavior in the pharmaceutical industry.

Keywords: advertising, product differentiation, marketing, market value, panel data, pharmaceutical industry

Frequent abbreviations
New chemical entity (NCE): drug that contains no active compound that has been marketed before.

Incrementally Modified Drugs (IMD): modifications of existing NCE's

1 INTRODUCTION

Popular press often claims that major pharmaceutical companies put more emphasis on marketing than on R&D (Public Citizen, 2001; Rellman and Angell, 2002). As a result of the entire lift of DTC advertising in 1997, drug companies' spendings on DTC advertising of drug products increased twice as fast as spending on promotion to physicians or on research and development in the period 1997-2005 (GAO, 2006). Over this period, drug companies spent less each year on DTC advertising ($4.2 billion in 2005) than on promotion to physicians ($7.2 billion in 2005) or R&D ($31.4 billion in 2005) (GAO, 2006). At the same time, the practice of line extension among major pharmaceutical firms has increased strongly over the past 30 years (Public Citizen, 2001; Craig and Malek, 1995, Relman and Angell, 2002; GAO$_2$, 2006).

Indeed, next to R&D expenditure, advertising expenditure is of strategic importance for firms' survival. Firms can use R&D and/or advertising expenditure as choice variables responding to increased competition. Indeed, past empirical studies in the various industries demonstrate the significant effect of R&D and advertising on firms' profitability (Griliches, 1981; Jaffe, 1986; Hall, 1993). The roles of

R&D and advertising, as well as product differentiation, are especially important in the pharmaceutical industry where firms do not fully compete in terms of price and products are highly differentiated (Matraves, 1999). The escalation of R&D, advertising and the vast increase of product modifications have been claimed to increase the economies of scale and contribute to the industry's high profitability (Matraves, 1999; Craig and Malek, 1995).

Scherer (2001) points out several ways in which R&D investment can be linked with profitability. First, successful R&D projects result in new roducts in the next period that eventually lead to profit. Second, high profitability can lead to increase in R&D expenditure in the next period. Although findings from studies on the link between internal funding and R&D are still mixed, pharmaceutical firms probably depend more on internal funding to finance their R&D activities than on external resources (Himmelberg and Peterson, 1994; McCutchen, Jr., 1993). Third, the link between profitability and R&D can be traced through the demand-pull mechanism in which expected profitability in certain therapeutical markets increases firms' R&D expenditure on that area (CBO, 2006).

Simultaneously, advertising can be linked with profitability in various ways (Erickson and Jacobson, 1991). First, advertising seeks to differentiate the firms' products and therefore can enhance brand loyalty and reputation. This loyalty and reputation can in turn enable firms to set higher prices than products with similar qualities. In addition, the long term effect of advertising can discourage potential entrants to enter in an intensive advertised industry (Waldman and Jensen, 2001).

Product differentiation is closely related with firms' advertising activities. In highly advertised industries, products are usually differentiated (Matraves, 1999). Product differentiation, accompanied with advertising campaigns, can affect performance through the process of enlarging consumer choice and through market segmentation that satisfies consumer demand more precisely (Connor, 1981). Additionally, in the U.S., product differentiation enables drug firms to obtain market exclusivity (Pattikawa, 2007). For example, when a drug company introduces an drug with a new chemical entity, it will be granted a marketing exclusivity for a period of five years. Within this period, no generic versions can be approved and therefore the company has the opportunity to invest in brand names. Furthermore, the company usually benefit from this exclusivity period by launching product extensions that can lead to additional marketing exclusivity period (Pattikawa, 2007; Pattikawa, 2006).

Scherer (2001) emphasizes the importance of R&D and advertising activities and argues that they play an important role in the concept of "virtuous rent-seeking" that characterizes pharmaceutical markets (Scherer, 2001). He describes this concept as follows: "… that is, as profit opportunities expand, firms compete to exploit them by increasing R&D investments, and perhaps also promotional costs, until the increases in costs dissipate most, if not all, supranormal profit returns…"

Despite the vast increase of advertising expenditure, as well as the high degree of product differentiation associated with it, few empirical studies examine their relationship with the profitability of pharmaceutical firms. Instead, the focus has been on the R&D role on pharmaceutical firms' profitability (Scherer, 2001; Grabowski and Vernon, 1990; Grabowski, Vernon and DiMasi, 2001; OTA, 1993).

Against this background, this paper studies the role of advertising and product differentiation for pharmaceutical firms' market value. Additionally, we want to compare the returns of advertising with that of R&D. Our study provides an opportunity to test the proposition that drug firms in fact put more

emphasis on marketing activities than on R&D. Our study contributes to the existing research in the following three ways. First, our approach enables us to investigate simultaneously the return of various intangibles assets of pharmaceutical firms that include R&D, advertising and product differentiation. Doing so allows us to compare the pattern of advertising returns with that of R&D over time.

Second, we are one of the first to study the impact of various intangible assets such as innovation, brand names and product introduction on U.S. pharmaceutical firms' market value over a long time period. Despite their valuable contributions, studies on the return of R&D in the pharmaceutical firms cover a relatively short period of time (Grabowski, Vernon, and DiMasi, 2001; Grabowski and Vernon, 1990). The relatively long study coverage allows us to asses whether there has been a shift in the patterns of the return of various assets of pharmaceutical firms. Furthermore, by examining these returns over a long time period we can gain a better understanding of pharmaceutical firms' behavior. This understanding can eventually be used to reduce the gap between private and social return (Hall, 2000).

Third, studies on R&D return in the pharmaceutical industry generally use accounting measures such as profits, sales or cash flows (Grabowski, Vernon, and DiMasi, 2001; Grabowski and Vernon, 1990). The time lags between the initial R&D decision and its final output in the form of new drug products provide limitations in measuring the direct impact of R&D on firms' profitability. Our study uses a market valuation model that provides an alternative solution to this problem (Griliches, 1981; Hall, 1993). This approach leaves the valuation of firms' strategic decision, including R&D, advertising and product differentiation strategies, to the financial markets. Using financial markets' evaluation avoids the problem of timing of costs and revenue described above and is capable of forward-looking evaluation, which traditional accounting approaches do not do well (Hall, 1993).

This paper is structured as follows. In the next section, we outline the theoretical framework based on the seminal work of Griliches (1981). Section 3 presents the methodology where we explain the independent variables in our model. This section also provides the data and the sample selection we used. Additionally, we present the estimation procedures we used and our model specifications. Section 4 discusses the results. Section 5 concludes the present paper by discussing the most important findings and their implications for innovation in the U.S. pharmaceutical industry.

2 THEORETICAL FRAMEWORK

Using market value to measure the return of intangible assets is based on the assumption that the value of company intangible assets, that include R&D, patents, advertising, and product differentiation, are determined frequently in the financial markets. The basic model hypothesizes that the market value of a pharmaceutical company is a function of all company assets, both tangible and intangible (Griliches, 1981; Hall, 2000).

$$V (A_1,A_2,A_3,\ldots) = f (A_1,A_2,A_3,\ldots) \qquad (1)$$

where f is an unknown function that describes how the combination of company assets creates value. Since the functional form of (1) is unknown, economists usually use an ad hoc linear function. Pioneered by Griliches (1981), this model gained popularity as indicated by a considerable number of papers using this model (for a review see Hall, 2000). This model is expressed as follows (for simplicity reasons we omit the time aspect):

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$$V_i (A,K) = q \, (A_i + \sum_{j=1}^{N} \gamma_j K_{ji})^\sigma \qquad\qquad (2)$$

where V_i is the current market value of company i as by the end of the year and A_i is the current value of the company's conventional assets. K_{ij} denotes the jth intangible asset of company i, and N is the total number of intangible assets. γ_j denotes the parameter of variable K, while q is the current market valuation coefficient of the company's assets, reflecting its differential risk and monopoly position (Griliches, 1981). From equation (2), we take the logarithm of both sides:

$$\log V_i = \log q + \sigma \log (A_i + \sum_{j=1}^{N} \gamma_j K_{ji}) \text{, which is equal to:}$$

$$\log V_i = \log q + \sigma \log [A_i(1+ \sum_{j=1}^{N} \gamma_j \frac{K_{ji}}{A_i})] .$$

Using the approximation that $\log (1+ x) = x$, we get:

$$\log V_i = \log q + \sigma \log A_i + \sigma(\sum_{j=1}^{N} \gamma_j \frac{K_{ji}}{A_i})$$

Letting $K_{ji}/A_i = I_{ji}$ and adding a disturbance term, we get the following empirical equation

$$\log V_i = \log q + \sigma \log A_i + \sigma \sum_{j=1}^{N} \gamma_j I_{ji} + u_i \qquad\qquad (3)$$

Under constant return to scale, this model implies that σ, the coefficient of $\log A_i$, is unity. Furthermore, the intercept of the model ($\log q$) can be interpreted as an estimate of the logarithmic average of Tobin's q for the sampled companies during the sample period (Hall, 2000).

3 METHODOLOGY
3.1 Independent Variables Included in the Model
We include the variables of interest in the equation 3; *R&D*, *advertising*, and *product differentiation*. As a measure of *product differentiation*, we use the annual number of product introductions that include NCEs and IMDs. Following Hall (1993), we include several control variables. We included *cash flow* (net of advertising and R&D) as a proxy for any market power or long-run profitability of companies. We also included the *growth rate of sales* in the present year to capture the prospects for future growth of pharmaceutical companies in our sample. Even though this variable might be a product of company's R&D and other investments, we assume that it is not completely captured by the current level of R&D expenditure (Hall, 1993). To control for specific industry movement, we included the weighted average of *industry return* in our model.

We excluded patent variables because we did not find any significant effect of patent variables in the initial analysis. For this purpose, we used several measures of patents, such as patent counts, patent citations, and importance of patent such as patent originality and generality[1]. The weak relation between

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[1] For more explanations on these terms see http://www.nber.org/patents/pat63_99.txt.

patents and market values can be traced to several factors. First, a review of existing studies shows that the patent is an indication of the same phenomenon as R&D variables but in a noisier way (Hall, 2000; Bosworth and Mahdian 1999). Second, R&D variables and patents did not always play significant roles when jointly included (Stoneman and Bosworth, 1994). Griliches, Pakes and Hall (1987) argued that patent count is a noisy measure of the underlying economic value of the innovations to which they are associated. Furthermore, patents have highly skewed distributions suggesting that few patents are highly valued and that many are worth little. Nevertheless, Hall (2000) argued that *weighted* patent, such as patent citation index, provides a better measure than simply counting the granted patent different measures of patent citations and the importance of patents. Our preliminary analysis showed, however, that these measures also had a negligible effect on firms' market value.

3.2 Model Specification

We specify two models. In the first model, we include the annual number of total products introduction as a proxy for product differentiation. In the second model, we split the product introductions into two categories; NCEs and IMDs. Doing so enables us to look at the individual effect of each of this product group.[1] In addition, we include the interaction variable of R&D and advertising to check whether the impact of R&D is strengthened by advertising and vice versa. Table 1 provides the definition of the variables used in the models. The two models can be specified as follows.

Model (1)

$$\log V_{it} = \log q_t + \sigma \log A_{it} + \gamma_1 R\&D/A_{it} + \gamma_2 Adv/A_{it} + \gamma_3 CF/A_{it} +$$

$$\gamma_4 \Delta \log S_{it} + \gamma_5 DCE_{it} + \gamma_6 (R\&D/A)*(Adv/A)_{it} + \gamma_7 Total_{it} + \gamma_8 Index_t + u_{it}$$

Model (2)

$$\log V_{it} = \log q_t + \sigma \log A_{it} + \gamma_1 R\&D/A_{it} + \gamma_2 Adv/A_{it} + \gamma_3 CF/A_{it} +$$

$$\gamma_4 \Delta \log S_{it} + \gamma_5 DCE_{it} + \gamma_6 (R\&D/A)*(Adv/A)_{it} + \gamma_7 NCE_{it} + \gamma_8 IMD_{it} + \gamma_9 Index_t + u_{it}$$

We perform regression analysis for the period 1971-2005. In addition, we also run a separate analysis for the two periods and see whether there is any shift of assets return from the first period (1971-1989) to the second period (1990-2005).

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[1] In the preliminary analysis, we also included the square terms of IMDs and the interaction term between IMDs and NCE, but we removed these terms because they did not have significant coefficient in any of the equation.

Table 1 Definition and Operationalization of Variables

Variables	Definition
$\text{Log } V_{it}$	logarithm of market value of company i at time t; market value is defined as stock price multiplied by number of outstanding stocks plus debt
$\text{Log } q_t$	intercept
$\text{Log } A_{it}$	logarithm of total tangible assets of company i at time t
$\text{R\&D/A}_{it}$	ratio of R&D expenditure to total assets
Adv/A_{it}	advertising to assets ratio
CF/A_{it}	cash flow to assets ratio
$\Delta\text{log } S_{it}$	growth of sales
DCE_{it}	debt to equity ratio; represents the capital structure of the company
$\text{R\&D/A}_{it} * \text{Adv/A}_{it}$	Interaction between R&D and advertising[1]
Total_{it}	number of total products launched (NCEs, IMDs and generics) in year t by company i[2]
NCE_{it}	number of NCEs introduced in year t by company i
IMD_{it}	number of IMDs introduced in year t by company i
Index_t	value weighted average of industry return

3.3 Estimation Procedure

A pooled test (Breusch Pagan multiplier test)[3], which tests the null hypothesis of whether a company's specific error term is zero, is significant at the 1% level ($\chi^2=25.66$). This indicates that performing ordinary least square (OLS) on pooled data will result in inefficient estimates. Therefore, we use *fixed effect* (FE) and *random effect* (RE) estimators that take into account companies' specific error terms (Verbeek, 2000). The FE estimator assumes that a company's specific effects are constant and do not vary over time. This is comparable to inserting a dummy for each company and applying OLS to the regression equation that is transformed into deviations from individual means.

The RE estimator, on the other hand, treats a company's specific error as a part of the error term. The RE estimator is a generalized least square (GLS) estimator that is obtained by exploiting the structure of the error covariance matrix (Verbeek, 2000). The Hausman test (Hausman 1978) can be performed to

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[1] We standardize R&D/A and Adv/A in the operationalization of this interaction variable.

[2] We do not divide the number of product introduction with total assets because it produces very small quantities that lead to substantially high coefficients. Therefore, we include the product's variable in absolute form, not in ratio like any other intangible assets.

[3] This test investigates whether the data can be pooled and ordinary least square (OLS) estimation can be performed.

choose between the FE- or RE- estimator. Under the null hypothesis that there is no correlation between company specific effects with the regressors both estimators are consistent but the RE estimate is efficient, while fixed effects are not. Under the alternative hypothesis that a company's specific effects are correlated with the regressors, RE estimators are inconsistent, while FE estimators are consistent and efficient.

3.4 Data Descriptions

For a detailed description on the selection of drug products and companies we refer to appendix A. We link the product database with financial data from COMPUSTAT. We replace missing values in advertising by using information from annual reports and by using extrapolation. For more details on this procedure we refer to appendix B. Industry index is obtained from the Kenneth R. French website[1]. The resulting database, after merging financial data and drugs approval data, comprises of 27 companies in the period 1971-2005. The minimal number of observation within one company is 6 and the maximal number is 35. As such, we have unbalanced panel data with 599 company-year observations.

4 RESULTS

In figure 1 we present the trend in the market value of pharmaceutical firms in our sample in comparison with the trend in NCE and IMD introductions in the period 1971-2005. This figure shows that there was a simultaneously sharp increase in the number of NCEs, IMDs and market value in the period 1994-1997. In 1996, the number of NCEs was at the highest in the history. At the same year, the number of IMDs also increased significantly compared to the previous years. A similar trend applies to the stocks valuation of pharmaceutical firms. After 1996, the number of NCEs has somewhat slowed down and reached the lowest in the past 30 years level in 2005. Meanwhile the market value and the number of IMDs stay at a relatively high level in that period.

Figure 2 shows the trend of R&D and advertising expenditures in comparison with market value. Both R&D and advertising expenditures have been increasing in the period 1971-2005. There has been, however, an increasing gap between these two figures. Since 1975, the R&D expenditure increased faster than that of advertising expenditure. Based on this figure, we can reject the claims that pharmaceutical firms spent more on advertising than on R&D expenditure (Public Citizen, 2001). However, we cautiously note that in our data advertising expenditure is likely an underestimation of the real figure, due to substantially missing values of advertising in COMPUSTAT (see also appendix B).

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[1] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

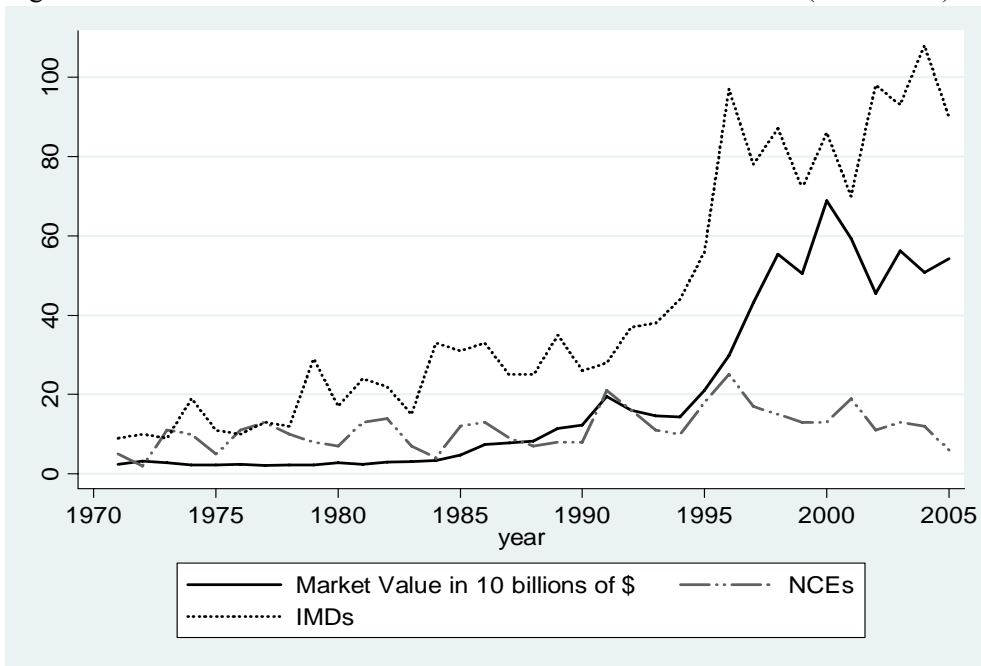Figure 1 Market Value and the Annual Number of NCEs and IMDs (1971-2005)

Figure 2 Market Value, R&D and Advertising expenditure of Pharmaceutical Firms (1971-2005)
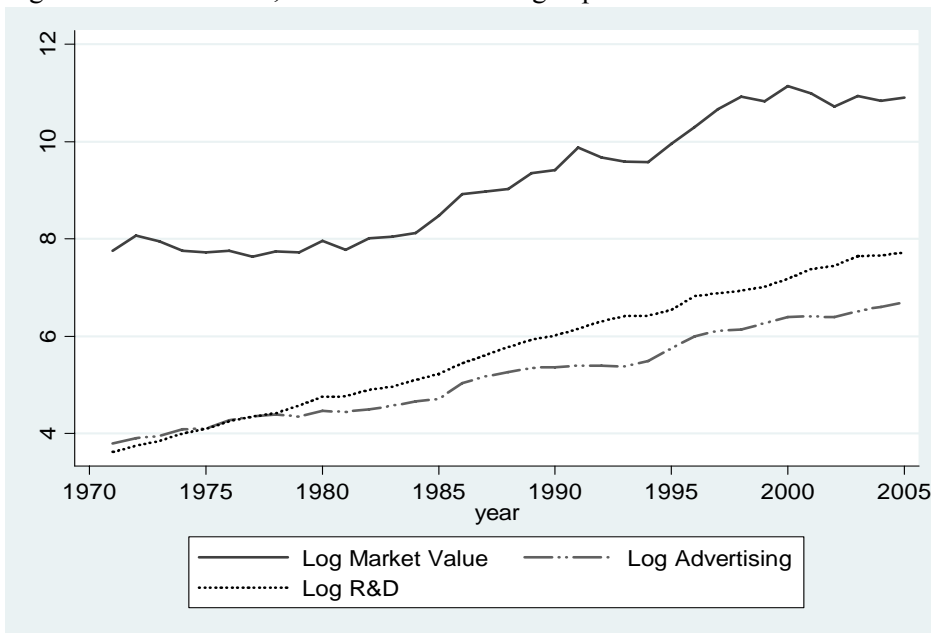
We present the descriptive statistics of the variables in table 2. We also provide separate descriptive statistics for period 1971-1989 and 1990-2005 in table 3 and table 4, respectively. On average, almost all assets increased from the first period to the second period. For example, the average of market value (in logarithm) has increased from 7.50 in the period 1970-1989 to 9.79 within the period 1990-2005. At

the same time, its volatility was somewhat reduced, as the standard deviation of this variable has decreased from the first to the second period. R&D to assets ratio and the degree of product differentiation in the second period was also higher than the first one. While a firm introduced on average 1.55 products in the period 1970-1989, it increased to 3.62 in the second period. A remarkable growth is observed for incremental products, which have increased from an average 0.86 to 2.90 introductions a year. There was also a slight increase in the average number of NCEs from the first to the second period.

Curiously, the intensity of outside debt has decreased. In the period 1970-1989, an average debt to equity ratio was 0.36, while in the period 1989-2005 it was only 0.16. This figure might support the position that pharmaceutical firms' are increasingly dependent on internal resources in financing investment activities (Scherer, 2001). Furthermore, despite the vast increase of advertising expenditure, the ratio of advertising to assets is relatively stable in the period under study. The same also applies to growth variable.

The estimation results of the three models for the whole period (1971-2005) are presented in table 5. Each model is estimated by three estimation procedures (OLS, FE and RE). The first three columns in table 5 present the estimates of model 1. The last three columns present the estimates of model 2, in which we split the product variable into NCEs and IMDs. The estimation results in the period 1971-1989 and the period 1990-2005 are presented in table 6 and table 7, respectively. All regressions are performed with robust variance estimate (Huber, 1967; White 1980; Rogers, 1993). Additionally, we exclude outliers that were under the 5% percentile and above the 95% percentile of the log of market value. As a result, the observations were reduced from 599 to 538. The minimal number of observation within one company was reduced to 2 and the maximal number stayed at 35.

Table 2 Descriptive Statistics, 1971-2005 (N=599)

Variable	Definition	Mean	St. Deviation
LogMV	Log market value	8.74	2.04
LogAssets	Log Assets	7.90	1.77
R&D/A	R&D to assets	0.09	0.05
Advertising	Advertising to assets	0.04	0.05
DCE	Debt to Equity	0.25	0.32
D log sales	Change in log sales	0.14	0.23
Product	Total products	2.68	3.14
CFA	Cash Flow to Assets	0.04	0.04
NCE	Innovative drug products	0.49	0.79
IMD	Incremental drug products	1.97	2.73

Table 3 Descriptive Statistics, 1971-1989 (N=271)

Variable	Definition	Mean	St. Deviation
LogMV	Log market value	7.50	1.81
LogAssets	Log Assets	6.96	1.52
R&D/A	R&D to assets	0.07	0.05
Advertising	Advertising to assets	0.05	0.06
DCE	Debt to Equity	0.36	0.43
D log sales	Change in log sales	0.14	0.25
CFA	Cash Flow to Assets	0.04	0.04
Product	Total products	1.55	1.86
NCE	Innovative drug products	0.40	0.69
IMD	Incremental drug products	0.86	1.26

Table 4 Descriptive Statistics, 1990-2005 (N=328)

Variable	Definition	Mean	St. Deviation
LogMV	Log market value	9.79	1.60
LogAssets	Log Assets	8.68	1.57
R&D/A	R&D to assets	0.10	0.05
Advertising	Advertising to assets	0.04	0.03
DCE	Debt to Equity	0.16	0.15
D log sales	Change in log sales	0.14	0.21
CFA	Cash Flow to Assets	0.04	0.05
Product	Total products	3.62	3.64
NCE	Innovative drug products	0.58	0.87
IMD	Incremental drug products	2.90	3.24

Table 5 OLS, Fixed Effects and Random Effects Estimation, 1971-2005 (27 companies, N= 538)

	Model 1			Model 2		
	OLS	**FE**	**RE**	**OLS**	**FE**	**RE**
Logarithm of Assets	0.929***	0.936***	0.926***	0.927***	0.935***	0.926***
	(0.018)	(0.019)	(0.019)	(0.018)	(0.020)	(0.019)
R&D to assets	2.266***	2.479***	2.388***	2.249***	2.481***	2.390***
	(0.670)	(0.579)	(0.528)	(0.702)	(0.578)	(0.528)
Advertising to assets	1.364*	1.801**	1.622***	1.351*	1.791**	1.614***
	(0.734)	(0.707)	(0.615)	(0.737)	(0.711)	(0.624)
Cash Flow to Assets	2.793***	2.870***	2.983***	2.807***	2.819***	2.940***
	(0.713)	(0.513)	(0.477)	(0.712)	(0.516)	(0.480)
Δ log sales	0.098	0.062	0.047	0.099	0.064	0.049
	(0.141)	(0.137)	(0.122)	(0.142)	(0.138)	(0.123)
Debt to equity	-1.685***	-1.662***	-1.579***	-1.675***	-1.663***	-1.580***
	(0.173)	(0.155)	(0.145)	(0.173)	(0.154)	(0.144)
Advertising x R&D	0.033	0.085**	0.077**	0.031	0.083**	0.076**
	(0.045)	(0.034)	(0.031)	(0.048)	(0.034)	(0.031)
Total	0.019**	0.018***	0.018***	_	_	_
	(0.008)	(0.006)	(0.006)	_	_	_
NCE	_	_	_	0.027	0.024	0.024
	_	_	_	(0.020)	(0.015)	(0.016)
IMD	_	_	_	0.019*	0.017**	0.017
	_	_	_	(0.009)	(0.008)	(0.007)
Industry Index	-1.565***	-1.684***	-1.704***	-1.568***	-1.680***	-1.701***
	(0.246)	(0.133)	(0.128)	(0.236)	(0.134)	(0.128)
R² ~	0.959	0.952	0.958	0.959	0.952	0.958
X² (Hausman Test) +		n.a. ^			n.a. ^	

Standard errors are in parentheses; *significantly different from 0 at 10%;** significantly different from 0 at 5%;*** significantly different from 0 at 1%;
$^+$Prob> χ^2 is in parenthesis; $^\sim$ R^2 refers to within R^2 and overall R^2 for respectively FE and RE. ^ not available due to small sample property

Table 6 OLS, Fixed Effects and Random Effects Estimation, 1971-1989 (18 Companies, N= 246)

	Model 1			Model 2		
	OLS	FE	RE	OLS	FE	RE
Logarithm of Assets	0.864***	0.816***	0.823***	0.865***	0.817***	0.826***
	(0.031)	(0.031)	(0.025)	(0.031)	(0.031)	(0.025)
R&D to assets	3.652***	4.035**	4.092***	3.646*	4.081**	4.134***
	(1.779)	(1.647)	(1.294)	(1.800)	(1.665)	(1.302)
Advertising to assets	2.096*	4.758*	3.851***	2.098*	4.779*	3.857***
	(1.125)	(2.739)	(1.213)	(1.133)	(2.756)	(1.213)
Cash Flow to Assets	2.501***	3.315***	3.146***	2.493**	3.227***	3.103***
	(1.085)	(0.775)	(0.725)	(1.101)	(0.780)	(0.731)
Δ log sales	-0.238***	-0.183***	-0.197***	-0.236***	-0.179***	-0.196***
	(0.054)	(0.067)	(0.063)	(0.055)	(0.068)	(0.063)
Debt to equity	-1.571***	-1.504***	-1.492***	-1.569***	-1.504***	-1.491***
	(0.194)	(0.197)	(0.170)	(0.193)	(0.119)	(0.170)
Advertising x R&D	0.111	0.252***	0.218***	0.111	0.255***	0.219***
	(0.090)	(0.091)	(0.059)	(0.092)	(0.092)	(0.060)
Total Product	0.016	0.017**	0.015*	_	_	_
	(0.010)	(0.008)	(0.012)	_	_	_
NCE	_	_	_	0.015	0.015	0.018
	_	_	_	(0.027)	(0.020)	(0.021)
IMD	_	_	_	0.018	0.021	0.015
	_	_	_	(0.016)	(0.014)	(0.014)
Industry Index	-1.388***	-1.169***	-1.216***	-1.391***	-1.166***	-1.217***
	(0.294)	(0.161)	(0.159)	(0.300)	(0.161)	(0.160)
R^2 ~	0.948	0.964	0.945	0.948	0.897	0.945
X^2 (Hausman Test) [+]		n.a. [^]			1.22 (0.995)	

Standard errors are in parentheses; *significantly different from 0 at 10%;** significantly different from 0 at 5%;*** significantly different from 0 at 1%;
[+] Prob> χ^2 is in parenthesis; ~ R^2 refers to within R^2 and overall R^2 for respectively FE and RE. [^] not available due to small sample property

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Table 7 OLS, Fixed Effects and Random Effects Estimation, 1990-2005 (25 Companies, N= 292)

	Model 1			Model 2		
	OLS	**FE**	**RE**	**OLS**	**FE**	**RE**
Logarithm of Assets	0.999***	0.998***	0.992***	0.999***	0.996***	0.991***
	(0.026)	(0.054)	(0.043)	(0.027)	(0.055)	(0.044)
R&D to assets	1.741**	1.888***	1.795***	1.752***	1.900***	1.804***
	(0.721)	(0.395)	(0.366)	(0.713)	(0.392)	(0.366)
Advertising to assets	3.625***	4.249***	3.741***	3.594***	4.209**	3.706***
	(1.039)	(1.185)	(0.956)	(1.055)	(1.194)	(0.977)
Cash Flow to Assets	3.239***	2.684***	2.861***	3.246***	2.640***	2.828***
	(0.709)	(0.965)	(0.764)	(0.709)	(0.966)	(0.771)
Δ log sales	0.540***	0.513***	0.516***	0.541***	0.517***	0.519***
	(0.121)	(0.113)	(0.108)	(0.120)	(0.111)	(0.108)
Debt to equity	-2.044***	-1.891***	-1.930***	-2.031***	-1.882***	-1.920***
	(0.230)	(0.268)	(0.210)	(0.233)	(0.268)	(0.210)
Advertising x R&D	-0.039	0.000	-0.008	-0.039	-0.003	-0.009
	(0.051)	(0.029)	(0.024)	(0.050)	(0.029)	(0.024)
Total Product	0.010	0.019**	0.016**	_	_	_
	(0.009)	(0.008)	(0.008)	_	_	_
NCE	_	_	_	0.016	0.020	0.017
	_	_	_	(0.026)	(0.018)	(0.019)
IMD	_	_	_	0.009	0.020**	0.017*
	_	_	_	(0.009)	(0.010)	(0.009)
Industry Index	-1.800***	-2.104***	-2.032***	-1.825***	-2.134***	-2.057***
	(0.350)	(0.353)	(0.361)	(0.341)	(0.349)	(0.357)
R^2 ~	0.949	0.875	0.948	0.949	0.876	0.948
X^2 (Hausman Test) +	1.84 (0.994)			1.29 (0.999)		

Standard errors are in parentheses; *significantly different from 0 at 10%;** significantly different from 0 at 5%;*** significantly different from 0 at 1%;
+ Prob> χ^2 is in parenthesis; ~ R^2 refers to within R^2 and overall R^2 for respectively FE and RE.

The R&D coefficients for the total period (1971-2005) are positive and significant, although they are relatively low compared to the past findings (Hall, 2000). Our R&D coefficients are centered approximately on 2.4, while findings from the past studies are centered on 5 or 6. Still, our R&D coefficients are within the range. The advertising coefficient is somewhat lower than R&D, which is approximately 1.8 in the regression over the whole period (1971-2005). Looking at the effect of product differentiation, our results show that product differentiation have positive impact on market value. In the period under study, an introduction of a new product increases the market value by approximately 18%. This effect is likely a result of the vast increase of IMD introductions since none of NCE coefficients is significant.

Comparing the results in the period 1971-1989 and that of 1990-2005, we found somewhat different patterns. In the period 1990-2005, we found that the coefficient of advertising to assets is almost three times as large as the coefficient of R&D to assets, while their coefficients are more or less similar in the period 1971-1989. In other words, the gap between the return of advertising and that of R&D becomes larger as we move from the first to the second period. Compared to Hall (1993) that found 4 to 5 times smaller advertising coefficients than that of R&D expenditures, our findings seem to show the opposite. The difference might be due to the nature of the industry; Hall (1993) study covered various U.S. industries, while we concentrate on U.S. pharmaceutical firms.

Additionally, we found a positive interaction effect between R&D and advertising intensities in the first period, which implies that their effects on market value strengthen each other. Nonetheless, this interaction effect is relatively small compared to the main effects. In the period 1990-2005, we do not find a significant interaction effect.

In the period 1971-1989, the impact of total product introduction on firms' market value is positive and significant. When we move from the first to the second period, this effect becomes slightly bigger. According to fixed effect estimator, an introduction of a new product in the period 1990-2005 will on average increase market value by 19%. Interestingly, similar with the regression results from the whole period, NCEs do not have significant impact on the market value in the period 1990-2005, while IMDs do. This is probably due to the relatively stable and small number of NCE introductions compared to that of IMDs.

 Looking at the control variables, the coefficients of cash flow to assets are positive and significant, which is line with the findings by Hall (1993). The impact of cash flow in the latter period, however, is slightly reduced compared to the period 1971-1989. As expected, the effect of higher debt leverage is negative and significant, which confirms previous findings (Toivanen, Stoneman, and Bosworth, 2002). This finding implies that high debt leveraged pharmaceutical firms are less valued than their peers with a relatively low level of external financing. The magnitude of leverage effects increases as we move from period 1971-1989 to the period 1990-2005. This finding shows that nowadays pharmaceutical firms are likely to be less dependent on external financing compared to the earlier period (1970-1989). The coefficient of industry index is negative and significant in all regressions, which indicates a negative relationship between pharmaceutical firms' market performance in our sample and the average return of all drugs firms. Note that the latter includes not only drug firms, but also, for example, biotech firms, medicine and chemical firms, and pharmaceutical preparation firms[7].

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[7] For details definitions of the industry portfolio we refer to
http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_49_ind_port.html

In contrast to previous findings (Hall, 1993), the coefficient of growth is not significant. This might indicate that pharmaceutical firms feed their growth mainly from R&D activities. In the period 1971-1989, the coefficients of growth of sales are negative and significant, while they are positive and significant in the second period. Looking at the whole period, the effects are negligible, perhaps as a result of the opposite results in the two periods. Assuming that we have specified the model correctly, one of the explanations of these findings is as follows. In the period 1971-1989, investors' expectations regarding the pharmaceutical firms' profitability was less optimistic than in the period 1990-2005. Prior to the 1990s, the increase in profitability due to the rise in sales was probably spent on the next period R&D, which eventually reduced the total amount for the dividend pay out. This is in contrast with the second period where investors' confidence was rising due to the vast increase of profitability. Noteworthy, this increasing optimism is probably due to the U.S. market trend in general (Pattikawa, 2007 see figure 3.13).

Summarizing, our results show the importance of advertising and product differentiation in stock market valuation of the U.S. pharmaceutical firms. Although the R&D expenditure is much higher than advertising over the years, since 1990, the returns of advertising have become three times as high as that of R&D. In addition, product differentiation has positive and significant effects on market value. This effect is probably a result of the vast increase of IMD introductions over the years.

5 CONCLUSIONS

In this paper, we examine the impact of advertising and product differentiation on pharmaceutical firms' performance. Our results emphasize the role of advertising and product differentiation in the virtuous rent-seeking behavior in the pharmaceutical industry. Despite the theoretical importance of these variables, the existing empirical studies mainly concentrated on the role of R&D in the profitability of pharmaceutical firms. Our study is important in that it provides a better understanding of pharmaceutical firms' behavior. This understanding can be used as part of policy makers and economists attempt to quantify the private returns on innovation and advertising activities in order assess their contribution to industry growth. In turn, this understanding can be a guide for strategies that aim to close the gap between private and social returns (Hall, 2000). In addition, our study also provides a possibility to test the claim of popular press that pharmaceutical firms put more emphasis on advertising than on R&D activities.

Our findings show significant impacts of advertising and product differentiation on firms' market value. In terms of expenditure, we do not find any evidence that pharmaceutical firms spend more on advertising than on R&D. After 1980, the R&D expenditure has always surpassed the advertising expenditure. However, our regression results show that nowadays the returns of advertising have become three times as large as that of R&D. This "opposite" findings can be interpreted in several ways. First, although the R&D is higher in the absolute terms, firms might use advertising more effectively. Furthermore, the rise in R&D expenditure does not necessarily lead to the corresponding increase of investors' optimism regarding firms' innovation performance. This is perhaps due to the fact that R&D expenditure is mainly withdrawn to finance minor innovations.

As expected, product differentiation has a positive and significant contribution to firms' market value. On average, an introduction of a new drug product increases market value by 18%. The role of IMDs herein is presumably of major importance since we found that the NCE introductions do not have significant effects. Nevertheless, the magnitude of the coefficients is larger than that of IMDs.

Relating our findings to the pattern of innovation in the industry, we argue that the explosion of market

value has not been the sole consequence of more innovation in the industry. The current behavior of drug companies, i.e. frequent launching of incremental drugs accompanied by effective use of advertising and the escalation of R&D expenditure, seems to get its reward in the financial market.

From the academic perspective, we show that incorporating a proxy for product differentiation can give a more complete picture of the fundamental values of publicly traded pharmaceutical companies. Although a company valuation has been intensively studied, existing research focuses primarily on the innovation input, i.e. R&D, or intermediate output (i.e. patents). Our study complements the existing literature by including final output of innovation activities in the model, measured by the number of product introductions.

As all research, we acknowledge limitations of our results. We have a considerable number of missing values for advertising in our dataset. Therefore, our results are depending on the accuracy of our estimates on the missing values of advertising. This, however, would have been overcome if pharmaceutical companies provided data on their advertising expenditures. Hence, we recommend that the drug companies should provide information on their advertising expenditures, aside from their administration and distribution expenditures. Additionally, information on DTC advertising can facilitate further research on the evaluation of public policy concerning advertising in the U.S. pharmaceutical industry.

In light of increasing attempts to limit consumers' exposure to false or misleading DTC advertising (GAO, 2006), studies on the persuasive versus informative role of DTC advertising will be an interesting and useful endeavor for future studies. Furthermore, we encourage future research to investigate the role of advertising and product differentiation at the product level. For example, one could investigate the impact of DTC advertising of a blockbuster on its sales. Such studies could give more details on the contribution of advertising. Additionally, such studies could compare R&D and advertising returns at the project level in order to assess their effectiveness. It is also interesting to generalize our findings to other high tech industries to see whether similar patterns exist.

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[8] http://ssrn.com/abstract=913474
[9] http://www.citizen.org/publications/release.cfm?ID=7065

APPENDIX A: DATA AND SAMPLE SELECTION OF DRUG PRODUCTS AND COMPANIES

The data of drug products are obtained from the Drugs@fda website.[10] This website provides a downloadable database file, which contains a zip file with seven text file documents containing a dataset on product approvals. For the purpose of our studies, we used three of them, namely: (1) RegActionDate.txt; (2) Application.txt; and (3) Product.txt.

For the explanation of each document, we refer to the website. We included only approvals with type N, S, SE1, SE2, SE3, SE4, SE5, SE6, SE7, SE8, SES, SED. These are approval types for NDA, ANDA, biologic drugs, and supplement types. For more detailed explanations of approval types we refer to the file DocType_lookup.txt on the website. We merged all three documents using STATA and produced 12.699 drugs approvals. The first approval date is on 11 November 1911 and the latest is on 26 August 2006[11]. Note that the next approval after 11 November 1911 is on 9 February 1939. Because of this large gap, we excluded the first approval of drug products in 1911 and therefore we cover the drugs approvals between the period 1939-2005. To avoid multiple counting, we count only once for drugs with the same active ingredient that was approved on the same day. For example, Ziagen, with active ingredient Abacavir Sulfate, was approved for the first time on 17 December 1998. This NCE was approved in two dosage forms, so it appears in the database twice. We count this only once and therefore the applicant had only one NCE approved on this date according the final data. Eliminating multiple approvals on the same day with the same active ingredients brings us to a number of 10.368 approvals in total. We assume that the day of approval is equal to the day of introduction.

A.1 CLASSIFICATION OF DRUG PRODUCTS: NCE, IMD AND GENERIC
The dataset provided by drugs@FDA does not allow us directly to distinguish drug products into NCE, IMD or generic. We used the following procedure. First, we identified generic applications as follows. We observed that generic application has application numbers between 40000 and 49999 or between 60000 and 89999[12]. Our procedure successfully traces generic drug applications and found that 5614 approvals (54%) are categorized as generic applications. This implies that the rest of the drug approvals, i.e. 46%, are NDA applications.

From the population of NDA applications, we distinguished NCE as the drug approval whose active ingredient has never been approved before. This implies that we categorized all drug products based on its active ingredient and ranked them by date of approval. The first drug product approved in a certain active ingredient category, i.e. the drug product that has the earliest date of approval, is classified as NCE. This procedure is performed in STATA. We found 1243 NCEs, or 12% of all drugs approved in the period 1939-2005. The rest is classified as incrementally modified drugs (IMDs). For example, fluoxetine chloride, known with trade marks Prozac or Sarafem, is first approved in 29 December 1987. Since that time until 31 December 2005, there were 67 additional drug approvals with this active ingredient (excluding drugs that combine this active ingredient with others), of which 55 are ANDA applications. The first approval in 1987

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[10] (http://www.accessdata.fda.gov/scripts/cder/drugsatfda)

[11] This is a generic application whose date is an expected date of approval. In many occasions, the expected date can be known in advance due to regulations (see section 2.2.1).

[12] This is after years of examination of the database. Additionally we took a random sample and check it manually. The results show that we can be confident about this classification.

is classified as NCE, 55 are classified as generic and the rest (12 approvals) are categorized as IMDs. Note that we took into account combinations and derivations of active ingredients in defining NCEs.

A.2 FIRM SELECTION

The dataset that is provided by drugs@FDA provides information on the sponsor companies of drug applications. In total, there are 596 different sponsor companies in the dataset in the period 1939-2005. We choose 27 companies in our final sample based on the following criteria. First, companies had to be listed in the U.S. stock market. Second, selected companies must have the majority of their product portfolios consisting of brand-name drugs, i.e. NDA approval. Especially, we limited the final companies to ones that have at least 50% of their total products consisting of NDA approvals. By doing this, we concentrated only on brand-name pharmaceutical companies and therefore excluded pharmaceutical companies that focus on producing generic drug products. Lastly, we required that selected companies must have at least four years of data on drug approvals and financial data. The final companies are the so-called *brand-name* companies, i.e. pharmaceutical companies that specialize in producing brand-name drugs.

We also took into account some major mergers and acquisitions in the pharmaceutical industry. From company website we traced that companies underwent a merger and/or acquisition. This is not always processed on time by FDA. We take this into account by looking at the year of the merger or acquisition and grouping drug approvals of both companies into one entity after the date of the merger. For example, Pfizer acquired Warner-Lambert Pharmaceutical in June 2000. Warner-Lambert brought two subsidiary companies; Agouron and Parke Davis. We grouped all drugs sponsored by Warner, Agouron and Parke Davies into Pfizer starting on 1 January 2001.

Figure A.1 provides the comparison of total NDA approvals and NDA approvals from our final sample. This figure shows that even though our sample does not cover the whole population, it does represent the industry trend.

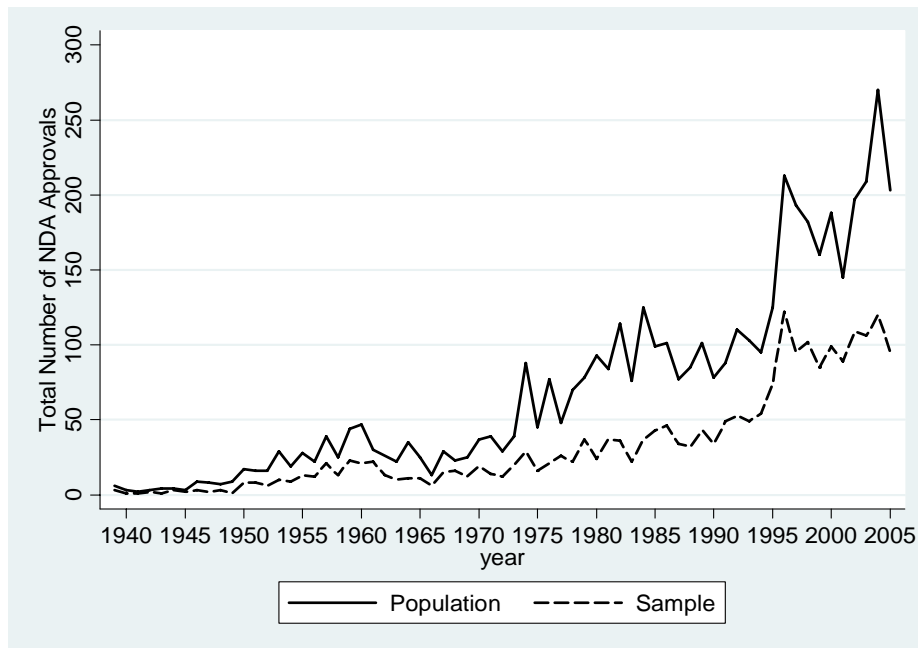Figure B.1 Comparison of NDA approvals in the population and in the sample

Table A.1 U.S. Pharmaceutical Firms Included in the Study

3M	Mallinckrodt
Abbott	McNeil Corp.
Allergan	Medicis
Amgen	Merck
AstraZeneca	Novartis
Bayer	Novo
Biovail	Pfizer
BristolMyersSquibb	Pharmacia
Forest Labs	Schering
Genentech	Schering Plough
GD Searle	Serono
GlaxoSmithKline	Shire
King Pharmaceuticals	Wyeth
Eli Lilly	

A.3 LIMITATIONS OF THE FDA DATABASE

The CDER database is limited in the sense that it only registers the latest sponsor of the drugs, not necessarily the one that introduced them in the first place. Once a company was taken over by another firm or merged with other companies, the database put all the drugs introduced by the initial companies into the new company[13]. Therefore, we only used data on introduction preceding a merger or acquisition. For example, we do not include GlaxoSmithKline, one of the big pharmaceutical companies, because we only have three years of accurate data after the big merger between Glaxo Wellcome and SmithKline in 2001. Before 2001, we cannot trace whether a particular drug belonged to Glaxo Wellcome or to SmithKline. Furthermore, we only include observations after year 1989 for Bristol Myers Squibb, the year in which Bristol Myers merged with Squibb.

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[13] We obtain data on merger and acquisition by consulting the company's history from the company, the Financial Times database, and CRSP.

APPENDIX B: REPLACING MISSING VALUES FOR ADVERTISING

In this appendix we describe the procedure of how we replaced missing values of advertising and how we came up with the final dataset used in the analysis. Financial data of companies in our data that was obtained from Compustat database had a considerable gap, especially in advertising data. We applied the following procedure to replace missing values of advertising. First, although Compustat contains financial data back in 1950, we only used observations after 1970. The main reason is that advertising data is not available for all companies prior to 1970. Moreover, advertising data is not available for all companies, even after 1970. Many companies in our dataset do not have consecutive financial data, including advertising, prior to 1980. Some companies do not even have data prior to 1990. By taking this into account, our final dataset is an unbalanced panel data, where few of the big players have data since 1971, while many others start much later.

This final dataset, however, still contains considerable gaps in advertising data; 32% of our final observations do not have advertising expenditure. This gap in advertising especially exists in the period 1993-2005. The staff of COMPUSTAT whom we contacted on this matter informed us that these companies did not provide the information on advertising data in this period.

To get more information, we consulted the companies' annual report via internet. Especially, we looked at the cost of selling or marketing at the financial statement of companies with considerable gaps in advertising expenditure. Because company usually only report the most recent annual reports, i.e. the last 5 years, we can only gather information after 1997. Financial statement reports the so called marketing and administration expenses and sometimes they also call it selling and distribution expenses. Indeed, we found different variations on the name of this account, such as: marketing & administrative; selling, administrative & general; marketing and selling; and marketing and distribution. We acknowledge that this account consists not only of advertising, but also other purposes such as administration, distribution and selling cost in general. Therefore, we use a proxy of this account to estimate the advertising expenditure. After replacing most recent missing values using information from companies' financial statement, approximately 18% of advertising data is missing. We replace the missing values left by linear extrapolation. Extrapolation is performed in STATA by using the ipolate command.

We used a trial and error procedure to determine the size of the proxy by comparing two figures; (1) the annual average of advertising values from original Compustat data that contains missing values and (2) the annual average of advertising values after replacing missing values with information from annual report and with extrapolation. Figure B.1 to B.4 show the comparison between the annual average of advertising from the original dataset and the annual average of advertising in the final dataset. The latter is obtained, as has been mentioned above, by using various percentages of marketing and administration (proxies), which is obtained from the annual report of companies. The solid line in each figure represents the annual average of available advertising expenditure of all companies in each year based on the Compustat data. The dashed line shows the average advertising data of all companies for each year, after (1) replacing the missing advertising data with various proxies (1 or 100%, 50%, 20%, and 10%) of marketing & administration from the annual report and, thereafter, (2) we replaced the missing values left by linear extrapolation.

As the above figure shows, advertising as a 20% of total cost of marketing & administration seems to be a reasonable proxy. We also consulted some information from companies that do provide advertising data. For example, in its notes to financial statements, Pfizer declares advertising expenditure in 2004 and 2005,

which is approximately 19% of total marketing and administration cost in that years[14]. We found a similar figure for Bristol Myers Squibb as well, one of few companies that reported advertising expenditure. Nevertheless, we acknowledge that companies such as Abbott and GlaxoSmithKline have lower actual proxies than 20% in the same years. Nevertheless, we think that 20% as is a reasonable proxy.

Our final financial dataset consists of 599 firm-year observations, ranging in the period 1971-2005 and consisting of 27 companies. Minimal firm-year observation for each firm is six years, and maximal is 35 years. This dataset is, therefore, an unbalanced panel data. In total, we use less than 599 observations, namely 596 observations for the regression analysis due to the use of sales in the previous year to calculate growth of log sales.

Figure B.1 The Original Versus the Final Advertising (Proxy=1)
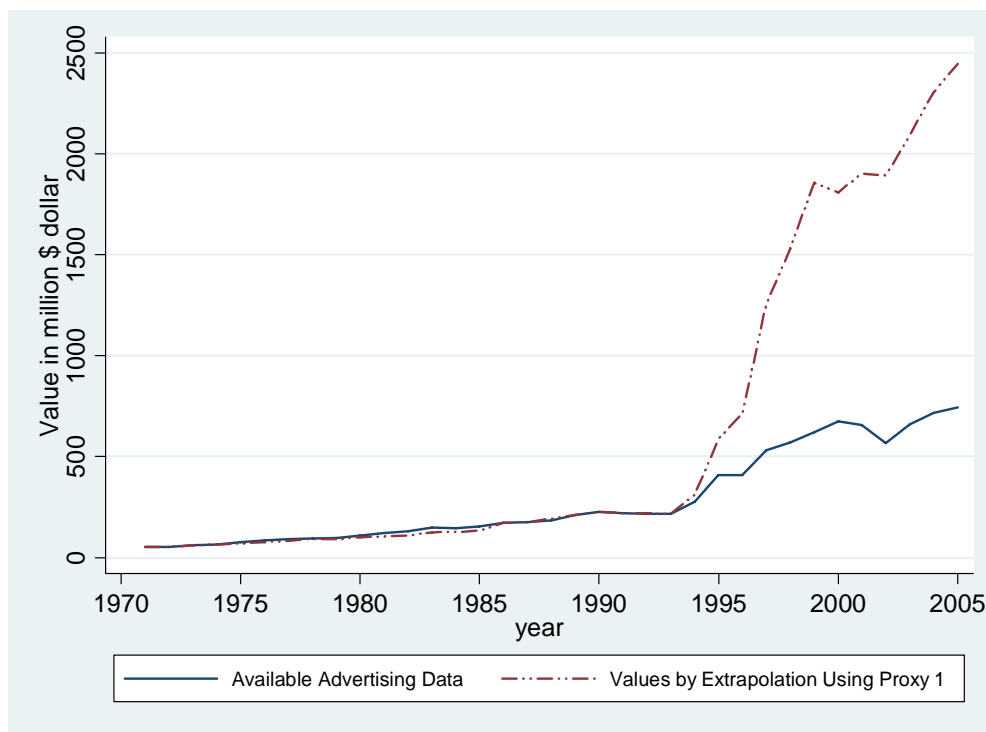
Figure B.2 The Original Versus the Final Advertising (Proxy=0.5)
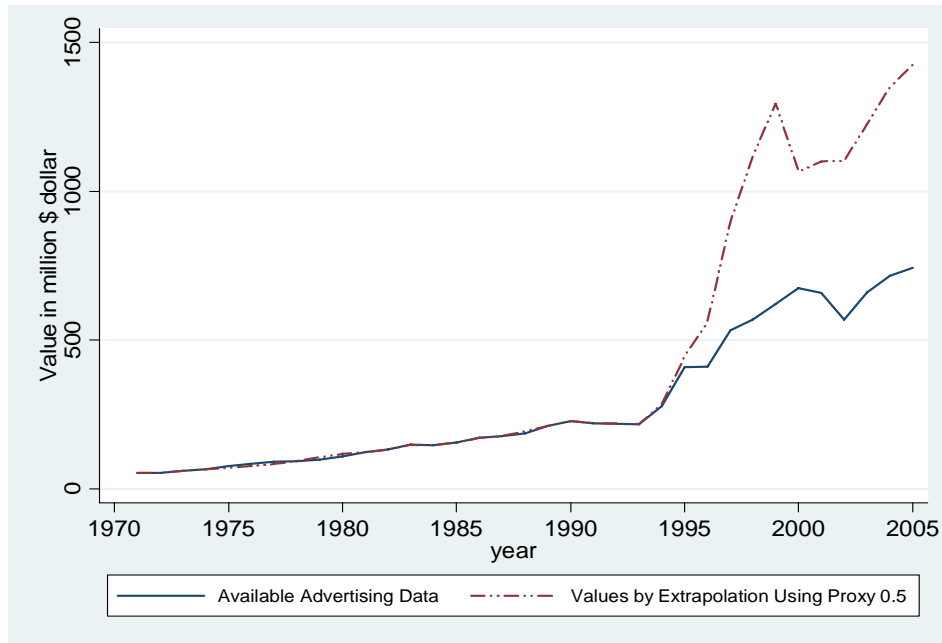

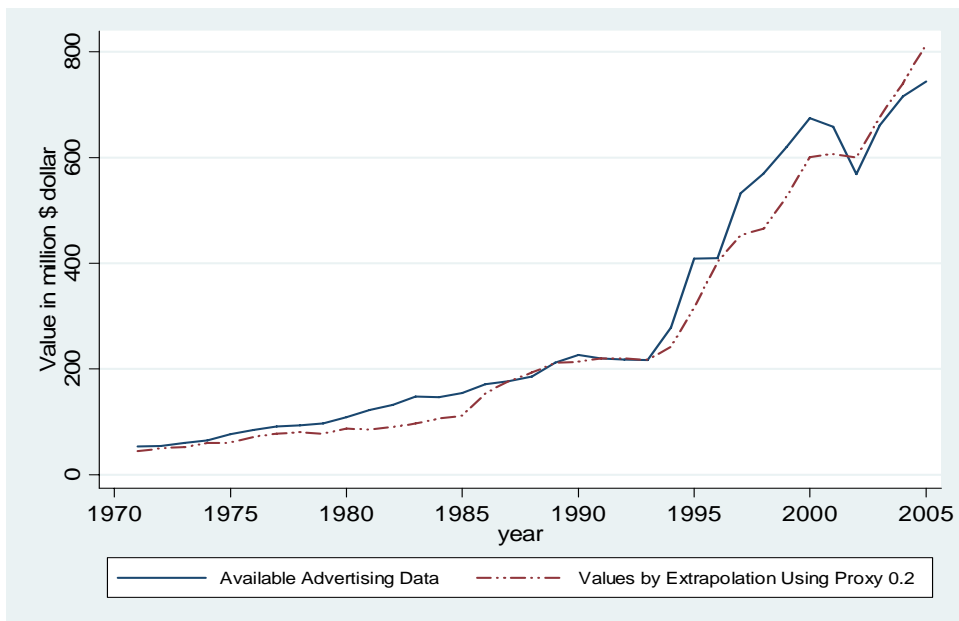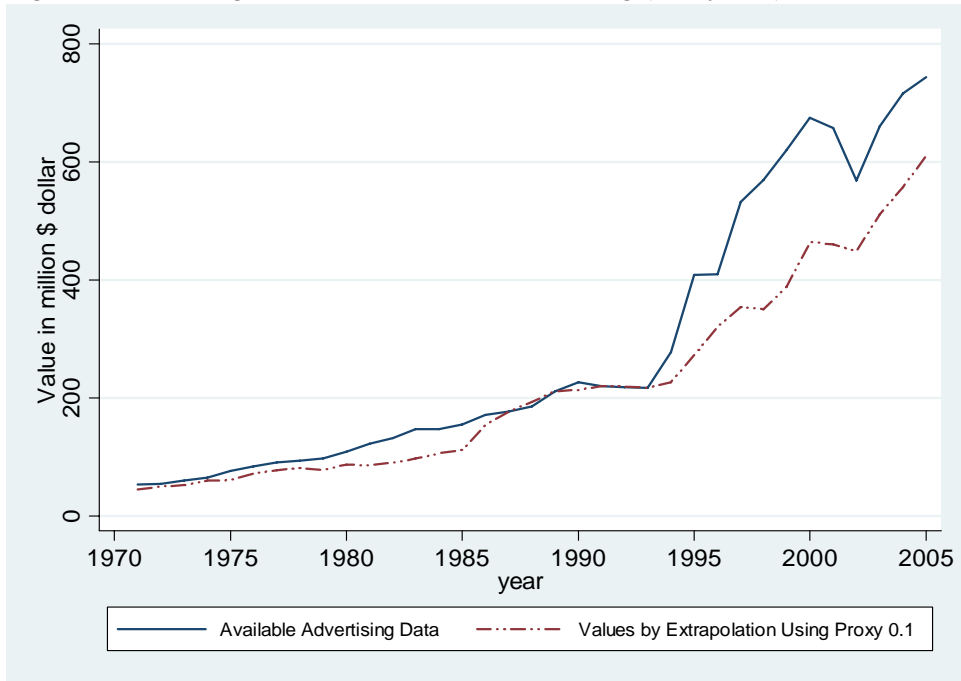Figure B.3 The Original Versus the Final Advertising (Proxy=0.2)

Figure B.4 The Original Versus the Final Advertising (Proxy=0.1)

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