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Do Public Announcements of Drug Development Events Influence a Drug Company's Market Value? A Study on Pfizer

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Abstract

The circulation of money in the global pharmaceutical market is substantial and has been increasing annually. Moreover, the high requirements for new drugs and the procedures for verifying the quality of drugs are increasingly complex; thus, successful drug research and development are critical for drug companies. To identify fluctuations in stock prices during the drug research and development process, the event study model is adopted to capture abnormal returns in Pfizer stock resulting from the public announcement of various relevant events. The study aims to (a) examine whether events publicized by official databases or the media during drug research and development affect Pfizer's stock price; (b) examine whether these events affect the stock price of Pfizer's competitors; and (c) compare price fluctuations around the dates of these events. The event data are collected from official databases, including the US Food and Drug Administration's *Orange Book*; clinicaltrials.gov; Web of Science; and media sources, such as the Wall Street Journal. The collected data span from the first date in each data source to December 31, 2018. The results reveal that Pfizer's stock price is affected by drug approval dates and trial judgment dates prior to media reports. However, the stock prices of other competitors are not correlated with Pfizer's stock price. Notably, a time gap between reporting from the Wall Street Journal and other data sources is identified. The results of this study can be useful for investors in the global stock market and for pharmaceutical companies exploring resource allocation in drug research and development strategies.

Keywords: Drug Development Process; Event Study; Pfizer

1. Introduction

A report by IQVIA Institute for Human Data Science (2021), which is a global market research institution, estimatesis study focuses on public announcements of drug development medicine market will be USD $1.6 trillion in 2025, not including spending on COVID-19 vaccines. The total cumulative spending on COVID-19 vaccines until 2025 is projected to be USD $157 billion primarily because of the first wave of vaccinations through 2022. The development of novel drugs is essential to the pharmaceutical industry (Lichtenberg, 2005). The pharmaceutical industry requires substantial funding for long-term research and relies on the advancement of science and innovative research and development (R&D) programs. Studies suggest that R&D has a strong effect on the market value of a pharmaceutical company (Chen & Chang, 2010). The market value of a company is its value according to the stock market and is defined by Nasdaq (2021) as the stock price multiplied by the number of

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shares outstanding. The stock price is the price at which a security is trading and can presumably be purchased or sold.

Various factors affect a company's stock price, including financial elements such as earnings per share, net assets per share, the growth rate of net investment, the quick ratio, and the total asset turnover rate. Public statements by companies also affect stock prices. These statements may be about financials, restructuring and management, insider transactions, and shareholder meetings (Stankevičienė & Akelaitis, 2014). Phase III clinical trials and Food and Drug Administration (FDA) regulatory decisions can also influence a company's market value (Overgaard et al., 2000; Rothenstein et al., 2011).

Before a drug is approved, several milestones must be achieved. The success rates for a new drug in each period of development are as follows: 51% during drug discovery, 60% during preclinical trials, 54% in Phase I clinical trials, 34% in Phase II clinical trials, and 70% in Phase III clinical trials. The success rate of the final new drug application (NDA) is 91%. Each phase requires substantial human resources and funding, and the risk of failure is high. The overall success rate from drug discovery to market entry is only 4.1% (Paul et al., 2010). The entire new drug development process typically lasts 10 to 15 years. Even if a drug is successfully patented, drug companies can still face litigation after the drug enters the market. Numerous studies have investigated drug development. Motohashi (2007) used qualitative interviews and determined that large drug companies used deductive methods, instead of conventional methods, to discover drugs. Some researchers have used factor analysis to identify "drug discovery" and "drug development" phases and examine the factors of drug productivity. These researchers have proposed that the success rates of clinical trials in Phase II and Phase III are key for increasing drug productivity (Paul et al., 2010). By considering the examination efficiency and the novelty of drug compounds, Sternitzke (2010) defined four drug categories and discussed the differences among drugs in terms of their knowledge sources, patent protections, and commercialization.

Studies have investigated the effects of drug development events on stock prices. Xu (2006) clearly demonstrated abnormal returns (ARs) for stock prices after the US FDA approval of new drugs. Liu (2006) discovered that the stock price is more affected by R&D breakthroughs and new drug approvals than by other events. After a drug patent expires, generic drug companies begin to produce the relevant drug; thus, the stock price of the inventing company substantially decreases. This phenomenon is called the "patent cliff." Lipitor (a Pfizer medication whose patent expired in 2011) is the most famous example of this phenomenon. Because of the expiration of the patent for Lipitor, the market value of world's top 10 drug companies declined by more than USD $95 billion from 2010 to 2013 (Ledford, 2011). Thus, critical drug development events considerably affect the market value of drug companies.

However, analysis by scholars has typically focused on a single event (e.g., new drug approval, R&D breakthroughs, or patent expirations). No studies have considered the overall effects of all drug development events. Furthermore, no studies have attempted to clarify the effect of drug development events for one company on

its competitors. In this study, the dates of major publicized drug development events are identified and their effects on stock prices are investigated. The investigated events are drug approval, patent expiration, clinical trial unblinding, research paper publication, and litigation verdicts. Pfizer is selected as a case study to analyze the effects of all observable events during drug development on stock prices. The research questions of this study are as follows:

(a) Do drug development events cause Pfizer's stock price to fluctuate?
(b) Do drug development events cause the stock prices of Pfizer's competitors to fluctuate?
(c) For drug development events with both an announcement in an official database and a report in the media, does Pfizer's stock price fluctuate on one, none, or both of the event dates?

2. Literature Review

Factors affecting a drug company's stock price, drug development, and observable events in each step of development are introduced in this section. Event study, which is a research methodology adopted to analyze the effects of visible events on stock prices, is also described.

2.1 Factors affecting stock prices

This study focuses on public announcements of drug development events and their effects on market value. Studies have demonstrated a relationship between stock prices and public announcements. Regularly scheduled macroeconomic announcements made by federal bureaus about employment, prices, and monetary policy affect stock prices (Kurov et al., 2019; Poitras, 2004). Public announcements issued by companies and read by investors also influence stock prices. Such announcements include statements about financials, restructuring and management, insider transactions, and shareholder meetings (Stankevičienė & Akelaitis, 2014). Reports of environmental pollution also affect stock prices (Rao, 1996). Technology transfer contracts affect market value in South Korea (Han & Lee, 2013). Phase III clinical trials and FDA regulatory decisions can affect a drug company's market valuation (Overgaard et al., 2000; Rothenstein et al., 2011). Engelhardt and Fernandes (2016) investigated the influence of leaked information by analyzing the effect of patent infringement verdicts on stock prices before and after the public release of the judgment and found evidence that some decisions were leaked before the public announcement. Gao et al. (2020) argued that news about competitor innovation eventually leads to informed trading of a (focal) company's stock and changes in its stock prices. Studies on the effects of events on stock prices have frequently used the event study model, and some studies have also used machine learning algorithms to forecast stock prices (Sedighi et al., 2019).

Although the aforementioned public announcements affect stock prices, all R&D events that may affect a company's stock price are not comprehensively understood. Moreover, to observe fluctuations in stock prices caused by these events, the announcement date of the events must be identified. Studies about stock price changes have not investigated differences between the official announcement of an event and its publication in the media.

2.2 Stages of drug development

Most studies have divided the drug development process into drug discovery, preclinical research, clinical trials, and NDAs (Sternitzke, 2010).

2.2.1 Drug discovery

Drug discovery is the process of discovering new drugs. Academic fields relevant to drug discovery include pharmacology, chemistry, and biology. The US FDA also claims that effective chemical compounds can be identified during drug discovery by using advanced techniques and conducting molecular compound trials. However, only a few compounds have the potential for further development.

2.2.2 Preclinical research

Preclinical research includes in vivo and in vitro studies. Researchers conduct animal testing to determine the toxicity and safety of new compounds. After animal testing, drug companies apply for investigational new drug status before performing clinical trials (U.S. Food and Drug Administration [US FDA], 2015). Usually, drug companies apply for primary drug patents during this stage (Abud et al., 2015). After a patent is granted, a company obtains 20 years for market exclusivity from the date of application for the new compound. Companies producing and selling patented drugs must have a license from the patent holder.

2.2.3 Clinical trials

Clinical trials typically involve three phases: Phase I, Phase II, and Phase III. Each phase involves more participants and lasts longer than does the previous phase. Phase IV clinical trials are conducted for a small number of new drugs. The primary purpose of phase I is to ensure the safety and understand the pharmacology of a drug in humans. The dose is increased to identify the maximum dosage and potential side effects. In Phase II, safety and side effects for different dosages are evaluated for a higher number of participants. Phase III is also known as the "critical trial phase." In this stage, single- and double-blind trials are conducted, and the obtained results are compared with those obtained for previously tested similar drugs to demonstrate that the new drug is more effective than previous drugs. In Phase III, long-term effects and rare side effects can also be identified. Phase IV occurs during the clinical stage before a drug is released and involves observing the results of the drug's widespread adoption for better understanding its rare but severe side effects. If a drug causes serious side effects, the drug is withdrawn from the market (US FDA, 2018). Patent applications also occur during the aforementioned phase. According to the results of clinical trials, secondary patent applications may occur. Secondary patents supplement primary patents by including changes in dosage, formula, or manufacturing.

2.2.4 New drug application

To improve the safety and effectiveness of drugs in clinical trials, drug companies submit clinical data to the FDA, which audits the new drugs and issues a license. Because audits and clinical trials are long processes, US patent law compensates for the lost time in the patent period by allowing patent term extensions (US FDA, 2020).

2.3 Observable events during drug development

Drug companies apply for primary patents to protect their preliminary research results. Some studies indicate that when drug companies

discover that a medicine can be commercialized, they are more willing to begin the patent application process (Sternitzke, 2010). Most relevant studies have indicated that patent application is critical for drug development because it prevents competitors from imitating the patented drugs (Levin et al., 1987) and effectively protects research results (Gambardella, 1995). Thus, more than 80% of drugs and 45% of drug developments will apply patents for R&D results protection (Arundel & Kabla, 1998). The patent application date is used as an observable event in this study.

Chong and Sullivan (2007) observed that drug companies that obtain licenses or fail in later clinical trials have the highest development potential. Drug development processes are faster and cheaper if related clinical studies have already been conducted. This result highlights the importance of clinical trials in drug R&D.

In clinical trials, an increase in patent applications is accompanied by an increased publication of research papers. If drug companies have a higher possibility of discovering new drugs, they are more willing to spend resources on related research. Thus, most drug research papers are related to clinical trials. According to previous studies, for each new drug developed, 19 journal papers are published and 23 patents are filed (Sternitzke, 2010), which indicates that a published journal paper is also an observable event in drug development.

In later stages of drug development, patented drugs can be released to the market after completing an audit. However, to encourage the development of generic drugs and enable patients to obtain cheap drugs, the US government has passed the Hatch–Waxman Act, which enables generic drugs companies to challenge drug patents. Patent holders also initiate patent infringement lawsuits against generic drugs companies to continue profiting from their patents and hinder generics from being sold (Panattoni, 2011).

In summary, this study regards the dates of patent granting, patent expiry, publication of clinical trial results, journal publishing, drug approval, drug expiry, and lawsuit judgments as the observable event dates for drug development.

2.4 Event study to analyze stock price fluctuations

Event study is the primary research method for analyzing events affecting stock prices. Event study is used to understand how events affect stock price trends. In addition to financial events, events can be related to management, accounting, economics, and other areas. Various business operation events are used to analyze stock price trends. Mc Namara and Baden-Fuller (2007) compared drug development events. In an event study, they observed that preclinical trials and NDAs are correlated with ARs. These two events are the conclusion of drug development periods, and the ARs for small companies are greater than those for large companies. Filson and Oweis (2010) regarded the date of drug companies developing an alliance as an event date. They found that when an announcement of an alliance is released, stock prices exhibit positive cumulative ARs. Moreover, drug companies prefer to make alliances during Phase III clinical trials, which is a result for the substantial R&D cost of this stage.

Mc Namara and Baden-Fuller (2007) examined financial markets by conducting an event study and found that the AR reached 5.71%

when large drug companies obtained an NDA. Sharma and Lacey (2004) considered the date when the US FDA approved or rejected a new drug as an event, and their investigation indicated that stock prices quickly reflect new events. The AR drug approved was 0.48%. By contrast, stock prices had an AR of negative 11.17% for a drug application failure.

Event studies can also be conducted to examine the effects on competitors' stock prices. Many studies have indicated that the announcement of an event causes inverse fluctuations in the stock prices of the relevant company and its competitors. Slovin et al. (1991) claimed that the effect of an announcement and the size of a company are negatively correlated. Thus, a report of a competitor's event has a stronger effect on smaller companies than on larger ones. Because large companies have diverse development programs, they can handle event announcements from competitors more flexibly than small companies can and are less affected than small companies are. Accordingly, the present study examines ARs for competitors' stock prices during drug development events.

3. Data Collection

This study collects information on crucial drug development events for Pfizer between October 31, 1980, and December 31, 2018. Official databases are used as sources because news organizations rarely report patent events. Litigation verdicts are reported by media outlets; therefore, media organizations are also used as a source for the dates of patent events.

3.1 Drug approval and expiration events

"PFIZER" is searched as a keyword in the "COMPANY" field in the *Orange Book: Approved Drug Products with Therapeutic Equivalence Evaluations* database of the FDA, and 173 drug certificate numbers are identified for Pfizer, including 113 drug approval dates. Some drugs have exact approval dates. We then download the *Orange Book* from 1980 to 2018 from the FDA website and examine the approval and expiry dates. A patent list and exclusivity expiration dates for each drug are listed in the Appendix of the *Orange Book*. The Wall Street Journal (WSJ) is also used as an event date source. "Pfizer" and "FDA" are used as search keywords. A total of 1,171 reports are identified and analyzed to find 36 unduplicated drug approval dates and 34 unduplicated exclusivity expiration dates.

3.2 Clinical trial announcement events

The clinicaltrials.gov website is searched using the "Sponsor/Collaborator" column with the keyword "Pfizer" to obtain 4,624 results. The WSJ is also used as a source of event dates. The Factiva database is searched with "Pfizer" and "clinical trial" as keywords and the WSJ as the source. A total of 835 reports related to clinical trials from Pfizer are obtained.

3.3 Journal publication events

We query "Pfizer" as a keyword for "institution search–advanced version" on Web of Science (WOS) and obtain 41,344 "articles." We extract the top 1% highly cited reports (i.e., 203 reports) to analyze the effects of published academic papers on stock prices. Highly cited papers typically have strong influences; thus, these papers are considered in the present study. WSJ is also searched with the

query "Pfizer" with "study" or "research," and 11 journal papers related to Pfizer are obtained.

3.4 Patent events

Orange Book editions from 1980 to 2018 on the US FDA's website are downloaded to collect information about Pfizer's approved drugs and patents. Pfizer obtained approval for 57 drugs linked with 122 patents during this period. According to the US Patent and Trademark Office, only 21 of these patents are assigned to Pfizer, whereas the others belong to other assignees. Thus, only these 21 patents are considered as the patent grant and expiration events in this study. The Factiva database is searched by using "Pfizer" and "Litigation" as keywords in the WSJ, and 687 lawsuits involving Pfizer are obtained. We classify these 687 lawsuits into three types of litigation verdicts: wins, settlements, and losses.

Finally, stock price information is downloaded from the New York Stock Exchange by using the Datastream database.

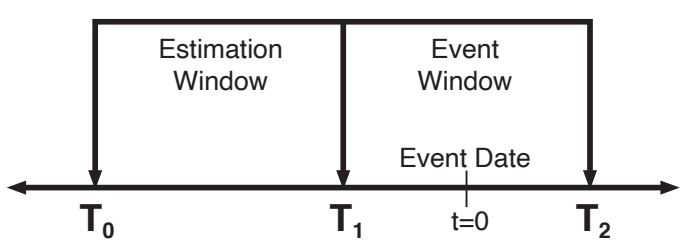
4. Event Study

4.1 Event date, event window, and estimation window

Event studies involve using financial market data to measure the effect of a specific event on the value of a company (MacKinlay, 1997). MacKinlay (1997) argued that given a rational market, an event immediately affects security prices. Thus, a measure to evaluate an event's economic impact can be developed by observing security prices over a short period. Event study windows are presented in Figure 1. The normal stock returns of the affected company (or companies) are estimated several days before and after an event (the event window). These normal returns are deducted from the actual returns to obtain the ARs attributed to the event. An estimation window (typically 120 days) is used to derive the typical relationship between the company's stock and a reference index through regression analysis. According to the regression coefficients, the normal returns are then projected and used to calculate the ARs (MacKinlay, 1997).

Event window lengths vary according to the event dates. Event dates are categorized as those from official databases and WSJ reports in this study. The event window comprises the period 3 days before and after the event date. The estimation window is set between 130 and 10 days before the event date (t = −130 to −10; half a business year comprises approximately 130 days).

Figure 1. Event Study Windows



4.2 Market-adjusted returns model in the event study

In their classic studies on event study methodologies, Brown and Warner (1980, 1985) suggested three models of normal returns: mean adjusted returns, market-adjusted returns, and market-and-risk-adjusted returns. Market-adjusted returns are popularly adopted in event studies and indicate that the normal return for a security at a given point in time equals the market return for that period. The expected returns for all securities are assumed to be the same during a given period even though they vary over time. This market model is the premise of the stock rate of return and market rate of return, which are linear measures, and uses the ordinary least squares regression method. The data from estimation windows for R_{mt} and R_t are used to obtain $\hat{\alpha}$ and $\hat{\beta}$, which are then added to the event date of R_{mt} to obtain the daily rate of return R_t. The relevant formula is as follows:

$$R_t = \hat{\alpha} + \hat{\beta}R_{mt} + \varepsilon_t \quad (1)$$

R_t: Actual rate of return on day t for Pfizer stock

R_{mt}: Period t of the rate of return of the market portfolio in the estimation window

$\hat{\alpha}$: Regression intercept term

$\hat{\beta}$: Regression slope

ε_t: Deviation term of Pfizer's stock under the assumption of a normal distribution $\varepsilon_t \sim (0, \sigma^2)$

4.3 ARs in the event study

An AR is the profit or loss generated by a given investment or portfolio over a specific period. ARs are calculated by deducting the returns that would have been realized if the analyzed event had not occurred (normal returns) from the actual returns of the relevant stock. Although the actual returns can be empirically observed, the normal returns must be estimated. The event study methodology involves using expected return models, which are also commonly used in other areas of finance research. Events are sorted into five types, and the AR is calculated for each event. We define the actual rate of return of sample stocks on the event date as R_{it}, remove the estimated normal returns by using the market regression model $E(R_{it})$, and obtain the ARs. The relevant formulas are as follows:

$$E(R_{it}) = \hat{\alpha} + \hat{\beta}R_{mt} \quad (2)$$

$$AR_t = R_t - E(R_t) \quad (3)$$

$E(R_t)$: Expected rate of return for the period t for Pfizer stock

R_{mt}: Market returns during the event

AR_t: ARs for the period t for Pfizer stock

R_t: Actual rate of return for the period t for Pfizer stock

5. Results

5.1 Event study for patent dates

5.1.1 Patent grant date

ARs are identified for 21 event windows. The p value for every event window is used to determine the significance of the AR. The relevant results are presented in Table 1. No significant AR is observed for Pfizer during the event windows. Thus, patent grants have no direct effect on Pfizer's stock price.

ARs for Pfizer competitors Merck and Johnson & Johnson are also presented in Table 1. Johnson & Johnson exhibits a significant increase in stock prices 3 days after the event date (t = 3). Furthermore, Merck exhibits significant increases in its stock price 1 day before (t = −1) and 2 days after the event date (t = 2).

Table 1. ARs for Patent Grant Dates for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	0.144	0.335	0.741	0.176	0.593	0.560	0.011	0.093	0.926
t = -2	0.246	1.085	0.291	-0.008	-0.029	0.977	0.140	0.992	0.323
t = -1	-0.300	-0.834	0.414	0.614	1.509	0.147	0.487	2.534	0.013**
t = 0	0.306	1.052	0.305	0.405	1.156	0.261	-0.132	-1.048	0.297
t = 1	-0.203	-0.776	0.447	-0.275	-0.881	0.389	-0.039	-0.301	0.764
t = 2	-0.775	-1.657	0.113	0.030	-0.798	0.434	0.216	1.883	0.062*
t = 3	0.723	1.512	0.146	0.055	1.807	0.086*	0.112	0.931	0.354

*$p < .1$. **$p < .05$. ***$p < .01$.

5.1.2 Patent expiration date

Table 2 presents the results for patent expirations. We collect Pfizer patent expiration dates before December 31, 2018. The stock prices of Johnson & Johnson and Pfizer have a significant negative AR 1 day before the patent expiration date (t = −1). The stock price of Merck has a significant negative AR in event dates (t = 1) and (t = 3) days after the event date.

5.2 Event study for clinical trial announcement dates

ARs for clinical trial announcements from official databases for Phase IV are calculated. A total of 209 dates are identified. A significant positive AR for Pfizer and a significant negative AR for Merck are observed 3 days following an announcement (t = 3) (Table 3).

Clinical trial announcements in the WSJ are also investigated. WSJ reports do not always include the trial phase; thus, these announcements are categorized as a success or failure. The analysis results for the 5 successful and 12 failed Pfizer clinical trial announcements are presented in Table 4. The stock prices do not fluctuate significantly with a successful or failed clinical trial announcement.

5.3 Event study for published papers

Publication dates from WOS and WSJ reports are used as event dates. Stock prices do not significantly fluctuate before or after an event for either reporting method (Table 5).

5.4 Event study for drug approvals and expirations

5.4.1 Drug approval date

ARs are calculated using 113 drug approval dates obtained from the FDA *Orange Book*. Table 6 reveals significant positive ARs for Pfizer (t = 3), Johnson & Johnson (t = -1 and 2), and Merck (t = -1 and 2).

ARs are also calculated for drug approval dates reported by the WSJ (Table 7). A total of 36 event periods are identified. A significant increase is observed for Pfizer stock 1 day before an announcement (t = −1); however, the ARs for Johnson & Johnson and Merck are nonsignificant.

Table 2. ARs for Patent Expiration Dates for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	0.861	1.688	0.108	0.118	0.510	0.616	0.280	1.262	0.222
t = -2	-0.004	-0.17	0.986	-0.186	-0.696	0.495	-0.487	-1.571	0.133
t = -1	-0.448	-1.891	0.074*	-0.371	-1.857	0.080*	-0.520	-1.594	0.127
t = 0	-0.309	-1.399	0.178	0.056	0.375	0.712	0.098	0.339	0.739
t = 1	0.358	1.095	0.287	-0.156	-0.444	0.663	-0.604	-2.069	0.052*
t = 2	0.353	1.454	0.162	0.032	0.119	0.906	0.444	1.127	0.274
t = 3	-0.02	-0.689	0.499	0.003	0.140	0.989	-0.425	-1.864	0.078*

*$p < .1$. **$p < .05$. ***$p < .01$.

Table 3. ARs for Clinical Trial Announcement Dates for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	-0.028	-0.378	0.706	0.027	0.443	0.659	0.021	0.295	0.768
t = -2	0.065	0.913	0.362	-0.049	-0.920	0.358	0.056	0.703	0.483
t = -1	0.013	0.167	0.868	-0.086	-1.348	0.179	0.027	0.275	0.783
t = 0	-0.077	-1.047	0.296	0.017	0.301	0.764	0.063	0.652	0.515
t = 1	0.053	0.815	0.416	-0.064	-1.035	0.302	-0.000	-0.004	0.997
t = 2	0.073	1.024	0.307	-0.032	-0.527	0.599	0.061	0.791	0.430
t = 3	0.14	1.940	0.054*	-0.084	-1.387	0.167	-0.146	-1.857	0.065*

*$p < .1$. **$p < .05$. ***$p < .01$.

Table 4. ARs for WSJ Clinical Trial Announcement Dates

Event date	Success			Failure		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	-0.063	-0.287	0.789	-0.219	-0.717	0.488
t = -2	0.079	0.486	0.652	0.860	0.248	0.809
t = -1	0.537	0.838	0.449	-0.166	-0.274	0.789
t = 0	1.481	1.364	0.244	-1.084	-1.044	0.319
t = 1	0.069	0.146	0.891	-0.491	-1.303	0.219
t = 2	0.258	0.257	0.601	-0.620	-0.966	0.355
t = 3	0.124	1.510	0.206	0.129	0.448	0.663

Table 5. Pfizer's AR for Papers Published by It

Event date	Published			Wall Street Journal Reported		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	0.135	0.930	0.355	0.164	0.482	0.640
t = -2	0.092	0.667	0.506	-0.664	-1.187	0.263
t = -1	-0.145	-0.959	0.340	0.156	0.228	0.825
t = 0	-0.019	-0.158	0.875	-0.134	-0.518	0.615
t = 1	0.161	0.987	0.326	-0.363	-0.541	0.600
t = 2	0.052	0.344	0.732	-0.228	-0.491	0.634
t = 3	-0.055	-0.036	0.972	-0.006	-0.015	0.988

Table 6. ARs for Drug Approval Dates for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	-0.047	-0.339	0.735	-0.033	-0.267	0.790	0.011	0.093	0.926
t = -2	0.089	0.574	0.567	-0.031	-0.215	0.830	0.140	0.992	0.323
t = -1	0.217	1.254	0.212	0.230	1.700	0.092*	0.487	2.534	0.013**
t = 0	-0.259	-1.510	0.134	-0.150	-1.282	0.203	-0.132	-1.048	0.297
t = 1	0.043	0.327	0.745	0.093	0.710	0.479	-0.039	-0.301	0.764
t = 2	0.201	1.602	0.112	0.225	2.011	0.047**	0.216	1.883	0.062*
t = 3	0.316	2.061	0.042**	-0.005	-0.046	0.963	0.112	0.931	0.354

*$p < .1$. **$p < .05$. ***$p < .01$.

Table 7. ARs for Drug Approval Dates Announced by the WSJ for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	-0.593	-1.609	0.117	-0.238	-1.364	0.181	0.101	0.763	0.451
t = -2	-0.017	-0.093	0.926	-0.220	-1.124	0.269	-0.054	-0.344	0.733
t = -1	0.446	2.121	0.041**	0.025	0.176	0.861	0.038	0.223	0.825
t = 0	-0.068	-0.281	0.780	-0.149	-0.848	0.402	0.146	0.842	0.406
t = 1	0.079	0.501	0.620	-0.075	-0.565	0.576	0.041	0.194	0.847
t = 2	-0.095	-0.417	0.679	0.127	-0.926	0.361	0.214	1.309	0.199
t = 3	0.054	0.213	0.832	0.082	0.779	0.441	-0.049	-0.306	0.761

*$p < .1$. **$p < .05$. ***$p < .01$.

5.4.2 Drug expiration date

A total of 34 drug expiration dates are identified (Table 8). All three companies have significant positive AR on the event date.

5.5 Event study for litigation dates

Identified litigation event dates are after the judgment. The event date is the date that the media (the WSJ in this study) reports the result to the market. Lawsuit loss events are not reported; thus, the dates are categorized as "wins" or "settlements."

5.5.1 Lawsuit win dates

AR results for lawsuit win dates are presented in Table 9. Six dates are identified. A significant positive AR is observed 1 day before a WSJ announcement (t = –1) for Pfizer and 3 days after a WSJ announcement for Pfizer and Merck (t = 3). A significant negative AR is observed for Johnson & Johnson 2 days before the announcement (t = –2).

Table 8. ARs for Drug Expiration Dates for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	-0.100	-0.311	0.758	0.070	0.302	0.764	0.070	0.302	0.764
t = -2	0.277	1.356	0.184	-0.067	-0.421	0.676	-0.067	-0.421	0.676
t = -1	0.095	0.430	0.670	0.034	0.247	0.806	0.034	0.247	0.806
t = 0	0.405	1.981	0.056*	0.440	1.769	0.086*	0.440	1.769	0.086*
t = 1	0.106	0.353	0.726	-0.136	-0.529	0.601	-0.136	-0.529	0.601
t = 2	0.294	1.052	0.300	-0.170	-0.878	0.386	-0.170	-0.878	0.386
t = 3	0.145	0.599	0.553	0.086	0.427	0.672	0.086	0.427	0.672

*$p < .1$. **$p < .05$. ***$p < .01$.

Table 9. ARs for Pfizer's Lawsuit Win Dates

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	0.003	0.007	0.995	-0.270	-0.671	0.532	0.820	1.127	0.303
t = -2	-0.007	-0.284	0.788	-0.705	-2.658	0.045**	-0.672	-1.902	0.106
t = -1	1.006	0.2442	0.058*	0.311	0.817	0.451	0.395	0.926	0.390
t = 0	0.420	0.838	0.440	0.491	0.648	0.546	-0.019	-0.068	0.948
t = 1	-0.304	-0.630	0.556	-0.084	-0.198	0.851	0.180	0.420	0.689
t = 2	-0.244	-1.054	0.340	0.221	0.366	0.730	-0.616	-1.761	0.129
t = 3	0.600	2.033	0.098*	0.367	1.128	0.311	0.906	1.988	0.094*

*$p < .1$. **$p < .05$. ***$p < .01$.

5.5.2 Litigation settlements

Three litigation settlement dates reported by the WSJ are identified, and corresponding ARs are calculated (Table 10). Pfizer and Merck have a significant positive AR 1 day (t = –1) before a settlement is reported. Johnson & Johnson has a significant negative AR 1 day before a settlement is announcement (t = –1) and a significant positive AR 1 day after a settlement is announcement (t = 1).

6. Summary

All significant ARs for Pfizer, Johnson & Johnson, and Merck during the event windows are presented in Table 11. Pfizer has positive significant ARs 3 days after clinical trial announcements, drug approval in an official database, and winning a lawsuit. Pfizer also has significant positive ARs 1 day before drug approval reported in the WSJ, winning a case, and settling a case. Strangely, Pfizer also has a positive significant AR for drug expiration dates. Competitor stock prices are not correlated to Pfizer's stock price. Event dates for media reports result in significant positive ARs for drug approval and winning or settling lawsuits.

7. Conclusions and Suggestions

This study examines the effects of events related to Pfizer's drug R&D on its stock price. We also compare the stock prices of Pfizer and its competitors during the aforementioned events. The conclusions regarding stock prices fluctuations, the limitations of this study, and related suggestions are presented in the following text.

7.1 Conclusions

Stock prices are affected before media announcements of drug approval, lawsuit victories, and reconciliation events. Stock prices have significant positive ARs before WSJ reporting but not before official database reporting. The day before the WSJ reports a drug approval, lawsuit victory, and reconciliation event, Pfizer's stock price increases by 0.45%, 1%, and 0.85%, respectively. The increase in stock price is the highest before the drug approval date.

Table 10. ARs for Litigation Settlement Dates for Pfizer, Johnson & Johnson, and Merck

Event date	Pfizer			Johnson & Johnson			Merck		
	AR (%)	*t*	*p*	AR (%)	*t*	*p*	AR (%)	*t*	*p*
t = -3	-0.243	-0.360	0.753	-0.126	-0.356	0.756	-3.840	-0.348	0.761
t = -2	-0.092	-0.176	0.877	0.940	2.320	0.146	-1.414	-0.268	0.814
t = -1	0.850	3.113	0.090*	-0.803	-6.701	0.022**	0.273	5.549	0.031**
t = 0	0.363	0.423	0.713	-0.080	-0.233	0.837	-3.162	1.005	0.421
t = 1	0.332	0.535	0.646	0.901	7.577	0.017**	-0.497	2.984	0.096
t = 2	0.609	1.092	0.389	0.955	0.933	0.449	-3.985	1.117	0.380
t = 3	0.662	0.791	0.512	0.110	0.197	0.862	-0.598	0.514	0.658

*p < .1. **p < .05. ***p < .01.

Table 11. Significant ARs for Pfizer, Johnson & Johnson, and Merck During the Event Windows

Event dates	t = -3	t = -2	t = -1	t = 0	t = 1	t = 2	t = 3
Patent Granted			Merck (+)			Merck (+)	Johnson (+)
Patent Expiration			Pfizer (-) Johnson (-)		Merck (-)		Merck (-)
Phase 4 in Clinical Trial Announcement							Merck (-) **Pfizer (+)**
Drug Approval (official)			Merck (+) Johnson (+)			Merck (+) Johnson (+)	**Pfizer (+)**
Drug Approval (WSJ)			**Pfizer (+)**				
Drug Expiration				Merck (+) **Pfizer (+)** Johnson (+)			
Winning Lawsuit (WSJ)		Johnson (-)	**Pfizer (+)**				Merck (+) **Pfizer (+)**
Litigation Settlement (WSJ)			Merck (+) **Pfizer (+)** Johnson (-)		Johnson (+)		

Note. (+) means positive AR rates; (-) means negative AR rates.

No correlation in stock price fluctuation is observed for Pfizer and its competitors, who might adopt strategy substitution. No correlation exists between the stock prices of Pfizer and its competitors, which supports the claim of Slovin et al. (1991) that announcement effects are negatively correlated with enterprise size. Large enterprises are rarely affected by event messages. They are more flexible than are small enterprises in their handling of competitors. Bulow et al. (1985) suggested that if an event can increase stock prices, competitors may perform strategy substitution in response.

Time lags differ between official databases and media reports for the same events. Critical moments for drug entry in an official database and reports by media have different time lags. Both these times cannot be estimated. Media reports are more likely to affect stock prices than are database entries.

7.2 Suggestions

7.2.1 Suggestions for investors

Pfizer's stock exhibits significant increases with drug R&D events, drug approval events, lawsuit victories, and reconciliation events before the reporting of these events in the WSJ. The stock no longer rises after the WSJ reporting date. Accordingly, if investors are informed about a drug R&D event by media, they cannot profit from this knowledge. They also cannot estimate the date of a media report by using the date of the event to profit from the stock market.

7.2.2 Suggestions for drug companies

Investors who receive news of Pfizer drug approvals have a positive attitude. Thus, Pfizer would continue to perform R&D to create more drugs and increase its stock price. News of winning or settling lawsuits also results in an increase in Pfizer's stock price. Thus, we suggest that drug manufacturers should play more positively in facing lawsuits to increase their stock prices. Media reports may cause the market to receive news even if stock prices fluctuate earlier. Publicizing events to the media is beneficial for drug companies.

7.2.3 Suggestions for academic research

Studies that have investigated drug R&D have focused on a specific event or on several event samples from numerous enterprises. However, the number of sample events in the aforementioned studies was insufficient and caused the statistical error. From reports about clinical trials from the WSJ, Hwang (2013) selected 24 clinical trial event dates for six drug companies. With few event dates and numerous drug manufacturers, the ARs of stock prices of drug manufacturers are likely to influence each other. Pérez-Rodríguez and Valcarcel (2012) selected extreme stock price ARs from the entire pharmaceutical industry for 261 samples. They then classified events as positive or negative according to increases and decreases, respectively, in stock prices and suggested reasons for the occurrence of a significant stock price AR on the day of a media report.

7.2.4 Limitations

In the FDA clinical trial database, the success or failure of clinical trials is not mentioned. Thus, we obtain the results of clinical trials by manually identifying judgments from WSJ reports, which reduces the number of samples. In the future, attempts can be made to identify clinical trial results from government data, thereby facilitating the understanding of AR for clinical trial dates. Moreover, no WSJ reports about Pfizer patents are identified; thus, these events cannot be identified in the present study. Future research can attempt to overcome this limitation.

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藥品發展事件的公告對藥廠市場價值之影響？以輝瑞公司為例

Do Public Announcements of Drug Development Events Influence a Drug Company's Market Value? A Study on Pfizer

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摘　要

全球藥品市場規模逐年增加，故藥品研發成功對藥廠至關重要。本研究採用事件研究法來探討輝瑞公司各類藥品發展事件的公告日前後股價異常收益。本研究目的(1)探討藥品發展事件在政府資料庫及大眾媒體報導等兩種公告日前後輝瑞公司股價波動，(2)檢視這些事件是否會影響輝瑞公司競爭對手的股價，以及(3)比較這些事件在公告日期前後的股價波動差異。研究結果顯示輝瑞公司的股價在媒體揭露獲得藥證和訴訟判決結果等事件前就已有顯著波動，但是其他競爭對手的股價不會與其連動。值得注意的是，大眾媒體的報導日期與政府資料庫的公告日期間存有時間差且股價波動也不同。本研究成果可作為股票投資時的判斷依據，以及藥品研發時的資源配置參考。

關鍵字：藥品發展歷程、事件研究法、輝瑞公司

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