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Product Liability Litigation: An Issue of Merck and Lawsuits Over Vioxx

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PRODUCT LIABILITY LITIGATION: AN ISSUE OF MERCK AND LAWSUITS OVER VIOXX

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ABSTRACT

Merck & Co., Inc. pulled Vioxx, a $2.5 billon a year nonsteroidal anti-inflammatory drug, off the shelf in September 2004. The removal followed a study that was published reporting Vioxx increased the risk of cardiovascular events after long-term use. In the years since then, many lawsuits have been filed against Merck. This paper examines the incentive to recall a product and the effects of Merck pulling Vioxx from the shelves. Using the market's expected internal rate of return for Merck, I calculate the expected profits from future Vioxx sales. I then use data on financial effects, along with the outcomes of cases already heard, to show how the market value of Merck reflects their probability of winning legal cases concerning Vioxx.

DEDICATION

I dedicate this work to my family.

ACKNOWLEDGMENTS

Special thanks goes out to Mike Maloney, Daniel Benjamin, Angela Dills, Chris Kirby, Curtis Simon, Patrick McLaughlin, Hillary Morgan in addition to seminars at Clemson and Seton Hall, and the Southern Economic Association Meetings for valuable comments and invaluable suggestions for this paper.

TABLE OF CONTENTS

Table of Contents (Continued)

LIST OF TABLES

List of Tables (Continued)

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

Merck and Co., Inc. withdrew Vioxx from the market in September 2004 after a study was published stating Vioxx increased the risk of cardiovascular events after long-term use.[1] There were, and still are, many legal cases from Vioxx patients that have been affecting Merck since the drug's removal from the market. This study uses an event-study format to find the market effects of the removal of Vioxx from the shelves. I observe that the market reacted completely and immediately to the announcement of Merck's decision, along with all other news announcements concerning Merck. Because the market reacted efficiently to Merck's decision to remove Vioxx from the market, the change in the market value of Merck will reflect the total damages expected to occur. This information allows me to analyze the timing of the withdrawal decision of Merck and also calculate the probability of Merck winning lawsuits against Vioxx. To do both of those, I will also find the total expected costs of the litigation issues brought against them.

The decrease in market value to Merck when they withdrew Vioxx from the market was $26.8 billion by the close of the market on September 30, 2004. This is not just expected litigation costs, but rather all costs expected from their decision. Merck had to pay direct costs for the recall, including all shipping and notification fees, along with the litigation

[1] Cardiovascular events are: myocardial infarction (heart attack), unstable angina, cardiac thrombus (blood clot), resuscitated cardiac arrest, sudden or unexpected death, ischemic stroke, and transient ischemic attacks (transient stroke).

costs. Furthermore, a large portion of that loss is not due to incurred costs, but the loss of expected profits that were imbedded in the stock price. When Vioxx was withdrawn, Merck still had approximately nine years of patent life left on a drug selling $2.5 billion a year. To estimate the lost profits, I obtain the market's expected internal rate of return for Merck.

With this information, I will determine if the timing of the withdrawal was at a profit-maximizing time for Merck. I will also show how the probability of a successful Merck lawsuit changes as new information becomes available. In chapter two, I will look at the incentives to withdraw the drug, and what the timing of the withdrawal means. Chapter three will look at what Vioxx is and has a brief timeline of Merck's history. Chapter four discusses the data and details an event study that shows the effects of the following events:

Event One – Merck removes Vioxx from the shelf.

Event Two – *The Wall Street Journal* reports that greater heart risk was known by executives.

Event Three – Merck loses part of their patent rights on Fosamax.

Event Four – FDA issues a release supporting Cox-2 inhibitors

In chapter five, I use an analysis of internal rate of return, along with the information obtained from the Fosamax patent loss, to estimate the loss in expected profits due do the Vioxx withdrawal. Using these events, I show how they explain the change in

probability of Merck winning lawsuits filed against them concerning the drug Vioxx in chapter six. The last chapter concludes and discusses future research possibilities.

CHAPTER TWO
MERCK'S TIMING

Merck withdrew Vioxx in 2004 when sales were $2.5 billion a year—as opposed to the $2 billion a year sales in 2000. In November of 2000, the *New England Journal of Medicine* published an article stating their VIGOR (Vioxx Gastrointestinal Outcomes Research) study found no significant increase in cardiovascular events, but problems around this article arose. Merck admitted that the data submitted to the journal to be published was correct, but before the study was published, new data arose stating that Vioxx did indeed increase the risk of cardiovascular events. Merck claimed that this information was revealed too late in the process to correct the article. If it was too late to re-write the article, there were still two other options available, they could have withdrawn the article completely or written a rebuttal in the following issue.

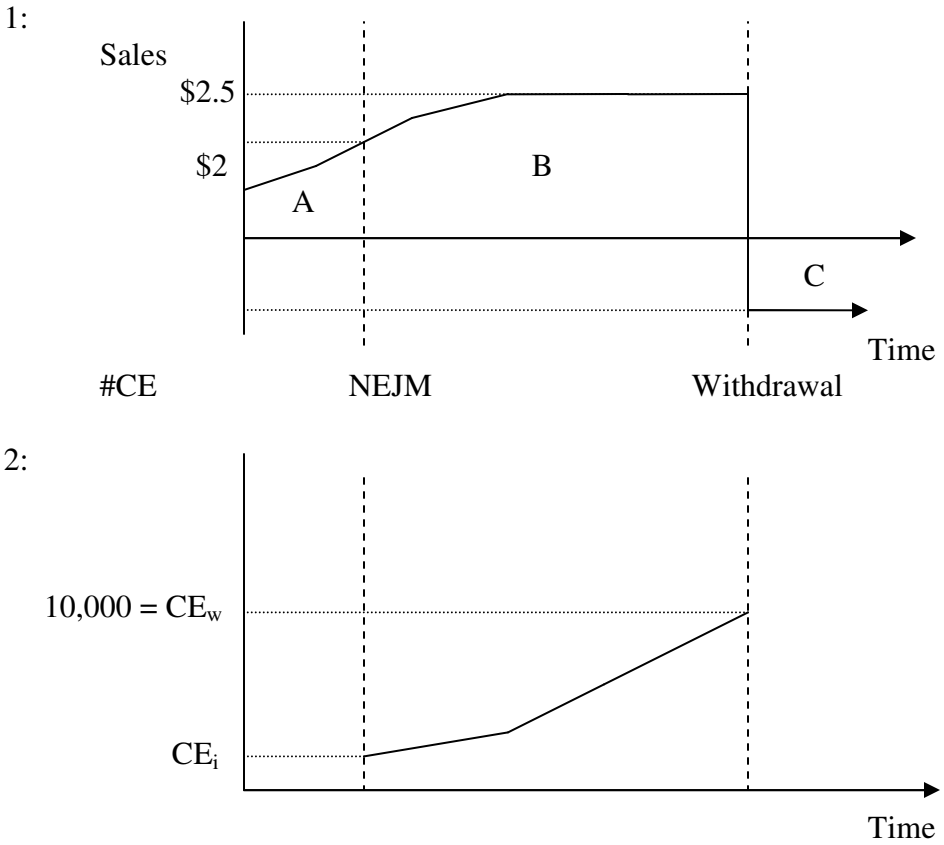

Figure 2.1 Timing of Withdrawal

In the above charts, NEJM is the date the *New England Journal of Medicine* published results from the VIGOR study, while Withdrawal is the date of the Vioxx withdrawal. The top graph shows the yearly sales of Vioxx from the FDA[2] approval date (May 1999) to the withdrawal date (September 2004). After that date, the negative number represents the loss in brand name capital caused by Merck's actions. The bottom chart shows the number of cardiovascular events caused by selling Vioxx. These cardiovascular events increase over time, as more people take the drug and longer usage causes increased risk. The graph shows no risk up to the point of the NEJM article, because up to that point, no

[2] FDA is the U. S. Food and Drug Administration, more information about the FDA can be found in Appendix C.

risk was known. When drug companies perform statistical analyses, there is a lag between people taking the drug and when they begin to show side effects. An example of the way in which more information becomes available over time is available in appendix A3 that looks at the increased risks of cardiovascular events found from the VIGOR study.

Section A (in part 1 of figure 2.1) shows the profits that Merck made from selling Vioxx before any knowledge of cardiovascular events (CE) were known. At the point of the NEJM, CE became known, so Merck had the choice to continue to market the drug or retract the publication and withdraw the drug at that time. When Merck found that Vioxx caused an increase in CE, there were a number of people already affected by the drug (CE_i), and the number of events continued to increase until the drug was withdrawn from the market (CE_w).

To determine why Merck waited to withdraw Vioxx until 2004, I compare the profits they received by keeping the drug on the market against the costs of doing so. To look at those numbers, I will compare area B's present value at the time of the withdrawal to area C's value along with all legal costs incurred, or expected to occur, at the time of the withdrawal. As you can see with part two of figure 2.1, as Merck continues to sell Vioxx, the number of cases of CE will continue to increase. The reason I compare it to the NEJM publication is that this is the first instance that Merck found risks of CE, thus if Merck would have removed Vioxx at this point, theoretically there would be no loss in brand name capital.

Because quality of a drug is hard to signal, companies try to signal to consumers the quality of their product through investments in brand names. Klein and Leffler (1981) argue that a company's investment in brand names and trademarks provide implicit guarantees to consumers of quality products. This idea has also been supported by many others including Klien, Crawford, and Alchian (1978) and Mitchell and Maloney (1989). They all claim that brand names are a quality assurance device.[3] The reason for establishing brand names is that it is not possible for companies to repeatedly fool their consumers about the quality of a product. Although a consumer could be fooled once, they would not be fooled again, and thus the investment in the brand name would be lost.

To find out if, and by how much, Merck benefited by keeping Vioxx on the market until 2004, I will have to find the present value of sales from Vioxx between the NEJM publication and the withdrawal. I will also have to find the total loss to the company due to brand name loss and litigation expenses. I have the sales of the drug over the years, but need to find the interest rate to discount the sales amount and the amount of sales that is profits. These issues will be addressed in chapter five. I also have to find the amount of brand name loss and expected litigation costs. Although I will not be able to separate those two effects out, I can find the markets expected loss when the withdrawal is announced. Chapter four will look at the market's reaction of the event, and to all other events, while chapter five will take out the expected future profits that were expected from the sales of Vioxx.

[3] Also supported by : Jarrell and Peltzman (1985), Chalk (1986 and 1987), and Benjamin and Mitchell (1989)

CHAPTER THREE
WHAT IS VIOXX?

Vioxx (rofecoxib) is a prescription medicine that is a Cox-2 (cyclooxygenase-2) selective inhibitor, nonsteroidal anti-inflammatory drug (NSAID). Vioxx is used to relieve the pain and inflammation of osteoarthritis and rheumatoid arthritis in adults. It is also used to manage short-term pain and treat menstrual pain and migraine headaches. The largest competitors to Vioxx are Pfizer's Celebrex and Bextra (Bextra has also been removed from the market) and Schering-Plough's Remicade, an international competitor. The other alternatives to these Cox-2 selective inhibitors (Vioxx, Bextra, Celebrex and Remicade) are nonselective inhibitors, such as naproxen and ibuprofen.[4]

Nonsteroidal anti-inflammatory drugs (NSAIDs) come as both non-selective and selective Cox-2 drugs. A non-selective inhibitor will inhibit both the Cox-1 and the Cox-2 enzymes. Research for these selective drugs began in 1991 when researchers first learned of the two different Cox enzymes. Although both enzymes help produce hormones called prostaglandins, Cox-1 is present throughout the body and Cox-2 is made only under certain conditions. The researchers found that only the prostaglandins made by Cox-2 enzymes lead to inflammation, pain and fever, while Cox-1 primarily makes hormones that help keep the stomach lining intact and the kidneys functioning properly.[5]

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[4] Examples of these are Advil and Motrin (ibuprofen) and Aleve (naproxen). Note: Tylenol (acetaminophen) is not considered a NSAID. Other Cox-2 selective inhibitors that came later are Merck's Arcoxia and Novartis' Prexige.

[5] From "Building a Better Aspirin" Pennisi, Elizabeth 1998

In the Research News from Pennisi (1998), John Breitner, an epidemiologist at the John Hopkins School of Public Health, said, "the potential long-term adverse consequences are not known," although the Cox-2 inhibitors seemed safe. Breitner notes that because the drugs seem so safe, people are likely to use them at higher doses for much longer than they would aspirin (because of its known risks). Non-selective NSAIDs cause an increased risk of stomach bleeding, ulcers, and potentially fatal stomach and liver damage. The risks non-selective inhibitors present are only found in a small number of people (estimates as low as 2-4 percent of those taking these drugs). For most Americans, ibuprofen or naproxen (non-selective NSAID's) provides the exact same pain relief as Cox-2 inhibitors at a fraction of the cost (naproxen retailed for approximately $0.06 per pill prior to its recall while Vioxx sold for as much as $3.00 per pill).[6]

Vioxx was launched in the United States in 1999 and has been marketed in more than 80 countries. In some countries, the product is marketed under the trademark Ceoxx. Worldwide sales of Vioxx were $2.5 billion in 2003. At that time, Vioxx was the third largest seller within Merck, following Zocor and Fosamax. This represented 11 percent of the $22.5 billion of total sales for Merck in 2003.

On September 30, 2004, Merck voluntarily withdrew Vioxx from sale. This came after a three-year study (called APPROVe, Adenomatous Polyp Prevention Vioxx) was done on the drug, concluding that subjects taking 25 mg of Vioxx had a higher chance of cardiovascular events, such as heart attack and stroke, than those taking a placebo. The increased health risks were occurring 18 months after the Vioxx treatment started.

[6] Retail prices from Community Catalyst, where naproxen is a generic while Vioxx still had exclusivity.

APPROVe was a multi-center, randomized, placebo-controlled, double-blind study to determine the effect of 156 weeks (three years) of treatment with Vioxx on the recurrence of neoplastic polyps of the large bowel in patients with a history of colorectal adenoma.[7] The trial enrolled 2,600 patients and compared Vioxx 25 mg to a placebo. The trial began enrollment in 2000.

"Merck has always believed that prospective, randomized, controlled clinical trials are the best way to evaluate the safety of medicines. APPROVe is precisely this type of study—and it has provided us with new data on the cardiovascular profile of Vioxx," said Peter S. Kim, Ph.D., president of Merck Research Laboratories. "While the cause of these results is uncertain at this time, they suggest an increased risk of confirmed cardiovascular events beginning after 18 months of continuous therapy. While we recognize that Vioxx benefited many patients, we believe [the removal of Vioxx from the market] is appropriate."[8]

[7] These neoplastic polyps are the negative effects that non-selective NSAID's, like naproxen, cause.
[8] From the "Statement Issued by Dr. Peter S. Kim at the FDA Advisory Committee Meeting" on February 17, 2005.

VIOXX (rofecoxib) is described chemically as 4-[4-(methylsulfonyl)phenyl]-3-phenyl-2(5H)-furanone. It has the following chemical structure:

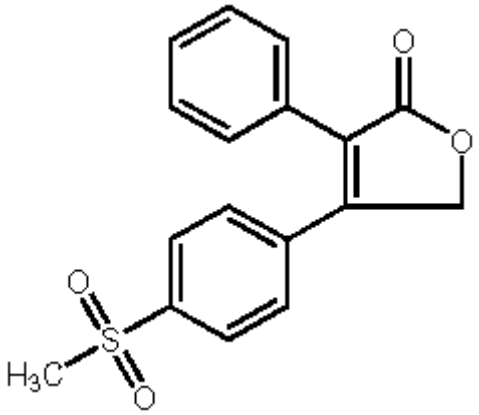


Figure 3.1 Chemical Makeup

Selective Time Line of Merck[9]

May 20, 1999	FDA approves Vioxx. (Closing price of $72.25, which is a one-day increase of 2.48%)
Nov. 23, 2000	VIGOR, which was designed to find the side effects of Vioxx, such as stomach ulcers and bleeding, is published in *The New England Journal of Medicine*.
Apr. 11, 2002	Merck revises the Vioxx label to include precautions about cardiovascular risk cited in the VIGOR trial.[10]

[9] A detailed timeline can be found in Appendix G.
[10] The VIGOR study found that of the 4047 patients taking rofecoxib, 111 had cardiovascular events (2.7%), while of the 4029 patients taking naproxen 50 had cardiovascular events (1.2%). This shows Vioxx has 2.2 times higher chance of having a cardiovascular event then does naproxen. This is a RR (relative risk) of 2.22 and a RD (risk difference) of 44%, found in Mukherjee, Nissen, Topol (2001).

Sept. 30, 2004 – 'Event One'	Merck voluntarily removes Vioxx from the shelves.
Nov. 1, 2004 – 'Event Two'	*The Wall Street Journal* reports that Merck executives were worried in the mid-to-late 1990's that Vioxx would show greater heart risk than cheaper painkillers.
Jan. 28, 2005 – 'Event Three'	The US Court of Appeals in Washington rules that the company will lose its patent on the osteoporosis drug Fosamax by 2008.
Feb 18, 2005 – 'Event Four'	The FDA releases an announcement saying they believe that the Cox-2 inhibitors' benefits outweigh the increased chance of a cardiovascular event caused by the drugs.
Aug. 19, 2005	Merck loses Ernst v Merck case.
Nov. 3, 2005	Merck wins Humeston v Merck case.
Dec. 12, 2005	Mistrial declared in Irvan v Merck.
Feb. 18, 2006	Merck wins Irvan v Merck case.

Apr. 5, 2006	Merck loses McDarby v Merck case, wins Cona v Merck case.
Apr 21, 2006	Merck loses Garza v Merck case.
Jul. 13, 2006	Merck wins Doherty v Merck case.
Aug. 2, 2006	Merck wins Grossberg v Merck case.
Aug 17, 2006	Merck loses Barnett v Merck case,[11] and Merck's November win is thrown out.

[11] Since this case, the judge ruled that the jury's verdict stating Merck is liable in the case will stand, but the $51 million in compensatory damages were unreasonable. (8/31/06)

CHAPTER FOUR
STUDY SET-UP AND DATA

For this study, I use stock market data on the daily returns for fifteen stocks in the drug industry and two proxies for the market. The proxies used are the Value-Weighted Index (VWI, value weighted stocks from NYSE, AMEX, and NASDAQ stock markets) and the Standard and Poor's 500 index (S&P). The AMEX Pharmaceutical Index (API, ticker DRG) includes the following fifteen stocks, which will be the pharmaceutical stocks analyzed in this paper.

Table 4.1 – Drugs in the API (AMEX Pharmaceutical Index):

Merck & Co	MRK
Pfizer, Inc	PFE
Johnson & Johnson	JNJ
GlaxoSmithKline plc Adr	GSK
Sanofi-Aventis Ads	SNY
Amgen Inc	AMGN
AstraZeneca Ads	AZN
Abbott Laboratories	ABT
Wyeth	WYE
Lilly (eli)	LLY
Bristol-Myers Squibb	BMY
Schering-Plough	SGP
Teva Pharm Indus Adr	TEVA
Forest Labs	FRX
King Pharmaceuticals	KG

The data is the daily close prices from the CRSP dataset (the Center for Research in Security Prices), up until December 31, 2005, and uses daily holding period returns. In 2006, Merck was the seventh largest company by market capitalization in the API, but before the withdrawal, Merck was fifth largest in the API and the second largest in terms of drug sales. I use this data to find not only the movement of the stock prices, but the movement of the stock prices relative to the rest of the market. I use the indices, VWI and S&P, as a proxy for the market.

Event Study

Following event-study methodology, I use a zero-one dummy variable to see if there is evidence of abnormal stock movements during an event.

$$R_t = \alpha + \beta R_{mt} + \gamma D_t + \varepsilon_t$$

I will be looking at the daily returns to stock prices relative to the market such that R_t is the return to Merck—or any given company—at time t, and R_{mt} is the market's return at the same date. D_t is a dummy variable that will take the value of one during the event window and zero the rest of the time. This methodology will directly test for any market effects to Merck, or any of the other companies, during the events in this study. Any significant effect on the term γ shows an abnormal return during that event window. Because the γ will be showing the abnormal returns, I will only report the coefficient and t-statistic on these, and not the α and β which only show Merck's average movement with the rest of the market.

The null hypothesis on the γ is that the stock has no abnormal return over that period. If γ is statistically different from 0, then the market had a reaction to the event, whereas if γ is not statistically different from 0, the event had no effect on that stock's price. To determine whether all information is captured the day of the event, or is an effect over a multiple-day period, I use event-study windows both including the event and excluding the event. This is informative because if γ is significant when the event date is included, but not significant when the event day is excluded, it symbolizes that full information was captured the day of the event.

To set this up, I first use a three-day event study. This means that there will be a zero for all dummies, except the three days in question.[12] The three-day study is done four times for each event. Two of the three-day event studies will include the day of the event, while the other two will not. I will check the reaction of the stock relative to the market both before and after the event, each with the event date and without the event date. The four event-study setups are shown below.

[12] The amount of days in the dummy variable seem to be arbitrary (also noted in Mitchell and Maloney 1989) as I get the same results when I follow the same methodology using five, seven, or ten day dummies as a robustness check.

Table 4.2 -- Event-study format for three-day event studies:[13]

Date																			
20	21	22	23	24	25	26	27	28	29	**30**	1	2	3	4	5	6	7	8	9	10
September											October									
0	0	0	0	0	0	0	0	0	0	**1**	1	1	0	0	0	0	0	0	0	0
Mrkone (Merck event one, three-day dummy including day of event)																				
0	0	0	0	0	0	0	0	0	0	**0**	1	1	1	0	0	0	0	0	0	0
Mrkonewoday (Merck event one, three-day dummy without day of event)																				
0	0	0	0	0	0	0	0	1	1	**1**	0	0	0	0	0	0	0	0	0	0
Mrkonebef (Merck event one, three-day dummy before the event including event date)																				
0	0	0	0	0	0	0	1	1	1	**0**	0	0	0	0	0	0	0	0	0	0
Mrkonebefwoday (Merck event one, three-day dummy before the event without event date)																				

After doing the three-day event study, I also repeat the same process for one and three months before and after the event (none of these studies will include the day of the event). The months after the event will reveal if the company is correcting itself from an "overreaction," whereas the months before the event will show if any information was acted upon before the announcement was public. I look at these month-long studies with caution, as events in this study tend to occur close in dates causing these longer studies to overlap. I do this for all fifteen stocks, each regressed against both indices using data for one year before and after the event.

[13] These event studies include data from one year before, to one year after the event. This table is shrunk down to ten days before and ten days after for demonstration purposes only.

Event One

Merck announced that it would remove Vioxx from the shelf September 30, 2004. The announcement was done after the markets closed September 29, 2004. The first event in this study looks at the effects of Merck's removal of Vioxx from the shelves. To do this, I look at the change from the close of the market on September 29, 2004 (before the announcement) to the close of the market on September 30, 2004. I look at the close because although a lot of information was revealed in the opening price (the opening price on September 30 was $33.40) on September 30, the change in price to the close that day allows investors to react to all information about the removal. The price of Merck's stock over two years, as well as the daily close percentage change, can be found in the appendix B.

Table 4.3 -- Event One, the change in price the day Merck removed Vioxx from the shelves, Sept 29, 2004 close to Sept 30, 2004 close.

Market Ticker	Close (9/29/04)	Close (9/30/04)	Percent Change
Merck & Co	45.07	33.00	-26.80%
Pfizer, Inc	30.18	30.60	1.40%
Johnson & Johnson	57.03	56.33	-1.20%
GlaxoSmithKline plc Adr	43.84	43.73	-0.30%
Sanofi-Aventis Ads	36.50	36.61	0.30%
Amgen Inc*	57.99	56.81	-2.00%
AstraZeneca Ads	41.27	41.13	-0.30%
Abbott Laboratories	42.31	42.36	0.10%
Wyeth	37.72	37.40	-0.80%
Lilly (eli)	61.85	60.05	-2.90%
Bristol-Myers Squibb*	23.86	23.67	-0.80%
Schering-Plough	18.50	19.06	3.00%
Teva Pharm Indus Adr*	26.48	25.95	-2.00%
Forest Labs	44.86	44.96	0.20%
King Pharmaceuticals	12.14	11.94	-1.60%

* - There was a change in shares outstanding during these days (the shares used are from the later date)

Table 4.4 -- Event One, the change in market capitalization the day Merck removed Vioxx from the shelves, Sept 29, 2004 close to Sept 30, 2004 close.

Market Ticker	Shares Outstanding In Billions	Market Cap (9/29/04)	Market Cap (9/30/04)	Gain (loss) September 30, 2004 in Billions of Dollars
Merck & Co	2.22	100	73.22	-26.78
Pfizer, Inc	7.55	227.88	231.05	3.17
Johnson & Johnson	2.97	169.27	167.19	-2.08
GlaxoSmithKline plc Adr	2.91**	127.57	127.25	-0.32
Sanofi-Aventis Ads	2.71**	98.92	99.21	0.3
Amgen Inc*	1.27	73.65	72.15	-1.5
AstraZeneca Ads	1.61**	66.44	66.22	-0.23
Abbott Laboratories	1.56	66.05	66.13	0.08
Wyeth	1.33	50.31	49.88	-0.43
Lilly (eli)	1.13	69.93	67.89	-2.04
Bristol-Myers Squibb*	1.95	46.41	46.04	-0.37
Schering-Plough	1.47	27.24	28.06	0.82
Teva Pharm Indus Adr*	0.45	11.91	11.67	-0.24
Forest Labs	0.37	16.61	16.65	0.04
King Pharmaceuticals	0.24	2.93	2.88	-0.05
			Sum:	-29.61

* - There was a change in shares outstanding during these days (the shares used are from the later date)
** - These stocks are held internationally as ADR,[14] the number used is the shares outstanding listed by Yahoo Finance

Visible from the one-day price changes, the large drop in Merck brought only a small increase in Pfizer and small losses in Johnson & Johnson, Lilly, and Amgen. The largest competitors to Vioxx are Pfizer's Bextra and Celebrex, Schering-Plough's Remicade, and nonselective inhibitors, such as naproxen and ibuprofen. The profits Vioxx previously

[14] More information about the ADR can be found in Appendix D.

benefited from are now expected to become profits to the competition. This will occur only if the market believes this is an issue with the Vioxx drug and not all Cox-2 selective inhibitors. If this increased chance of cardiovascular events is thought to be caused by all Cox-2 drugs, then the market will worry that Pfizer and Schering-Plough will also be battling lawsuits in the near future. Evidence later reveled that this is an issue as all Cox-2 selective drugs are dealing with similar lawsuits and have had to change their labels to include warnings of heart risk. Because of an increased risk of cardiovascular events in all Cox-2 selective inhibitors, the increase in price for Pfizer and Schering-Plough may not be a significant change from the market that day.

The number of shares outstanding multiplied by the price change will make known the change in the market capitalization within each company. At the time, Merck had 2.2 billion shares outstanding, meaning that the $12.07 overnight loss to the stock price represents a market value loss to Merck of $26.8 billion. That same day, Pfizer had an increase of $3.2 billion and Schering-Plough had an increase of $0.8 billion, while Johnson & Johnson lost $2.1 billion, Lilly lost $2 billion, and Amgen lost $1.5 billion. The net loss to these fifteen stocks that day was $29.6 billion (the overnight loss was $16 billion). This loss represents the total expected loss due to Merck's decision to remove Vioxx from the shelves. The loss to Merck was $26.8 billion, while the difference between Merck's loss and the total drug industry loss was $0.8 billion. So at first thought, the $0.8 billion difference would capture the expected loss to the industry from the effects of the Cox-2 inhibitors. But before we explore that idea, let's first see if indeed the market captured all information that day.

Table 4.5 – Event One, three-day study including event day and without event day: September 30, 2004

Company	Mrkone (Event One With Day)		Mrkonewoday (Event One Without Day)	
	VWI	S&P	VWI	S&P
Merck & Co	-0.081 (7.71)**	-0.081 (7.76)**	0.002 (0.16)	0.001 (0.13)
Pfizer, Inc	0.007 (1.04)	0.007 (1.04)	0.003 (0.43)	0.003 (0.37)
Johnson & Johnson	-0.002 (0.44)	-0.002 (0.49)	0.003 (0.71)	0.003 (0.64)
GlaxoSmithKline plc Adr	-0.007 (1.17)	-0.007 (1.15)	-0.004 (0.63)	-0.004 (0.65)
Sanofi-Aventis Ads	-0.002 (0.22)	-0.002 (0.19)	0.001 (0.11)	0.001 (0.11)
Amgen Inc	-0.009 (1.12)	-0.009 (1.11)	-0.002 (0.26)	-0.002 (0.3)
AstraZeneca Ads	-0.008 (1.02)	-0.008 (1.01)	-0.008 (1.02)	-0.008 (1.04)
Abbott Laboratories	-0.005 (0.86)	-0.005 (0.87)	-0.005 (0.76)	-0.005 (0.81)
Wyeth	0.003 (0.42)	0.003 (0.42)	0.005 (0.61)	0.004 (0.57)
Lilly (eli)	-0.007 (0.89)	-0.007 (0.9)	0.006 (0.83)	0.006 (0.79)
Bristol-Myers Squibb	0.002 (0.38)	0.002 (0.4)	0.003 (0.47)	0.002 (0.43)
Schering-Plough	-0.006 (0.71)	-0.006 (0.71)	-0.015 (1.87)	-0.015 (1.93)
Teva Pharm Indus Adr	-0.006 (0.71)	-0.006 (0.67)	-0.009 (1.03)	-0.009 (1.03)
Forest Labs	0.003 (0.29)	0.003 (0.3)	0.012 (1.05)	0.012 (1.04)
King Pharmaceuticals	0.01 (0.63)	0.01 (0.63)	0.015 (0.96)	0.014 (0.95)

* significant at 5%; ** significant at 1%, Absolute value of t statistics in parentheses

Although Pfizer and Schering-Plough are the two largest competitors, neither of their coefficients are significant when the event date is included (nor are any companies other then Merck). This shows that their movement is not abnormal from the market

movements; therefore, their gains that day were not necessarily due to the Vioxx announcement. There are two contradictory pressures on the prices of Vioxx's competitors. One is that they will increase sales making up for Vioxx's lost sales, while the other is the chance that all Cox-2 inhibitors could increase cardiovascular events. Because of this, the price changes expected to Pfizer and Shering-Plough are ambiguous.

I use the two initial regressions discussed earlier: first, the three-day dummy including the day of the event (mrkone - Merck's event one), and then the three-day dummy not including the day of the event (mrkonewoday - Merck's event one without the event day). As you can see from the regressions above, Merck is significant when the event day is included, but not significant when the event day is not included. Merck is also the only company that moves statistically different from the market. This shows that all information was included the day of the event and that Merck is the only company that was significantly affected by the event. The same thing is found when looking at the three days leading up to the event. To do that, I use the same three-day event study looking at the days leading up to the event, which is found in the appendix along with one and three months before and after the event (appendix B tables B1-3, B1-4 and B1-5). This reveals two pieces of information, that the day of the event captured all information and also that there is no evidence of insider trading.

Other Events

The same event-study format is used for all four of the events in this study. As the first event was fully captured the day of the event, the same was found with the other three events as well. The second event occurred while the markets were closed, while the other events all occurred while the market was open. I will compare the one-day price change to see what effect that event had on Merck's market capitalization. I will also look at the market capitalization change for events that occur beyond the dates of the four events in the study; however, these events use data from Yahoo Finance as CRSP is updated yearly and only has data through December 31, 2005.[15] The events in this study include information announcements, but in addition, I will also look at the price changes along with the market capitalization changes for all legal cases heard up to this point.

The second event was when the *Wall Street Journal* published an article claiming that Merck executives had knowledge of the increased risk of cardiovascular events well before they withdrew the drug. This event was expected to have a negative effect on Merck because it revealed information that could cause the market to believe that they would lose more lawsuits, so this drop in market value will fully reflect a decrease in the probability of Merck winning cases. This event caused Merck's stock price to decrease by 9.7 percent.

The third event had no direct effects on the lawsuits filed against Vioxx. This event was when Merck lost the last ten years of patent life of Fosamax, their second-largest-selling

[15] The data using CRSP was also done using Yahoo Finance and they revealed the same information.

drug. Teva Pharmaceuticals challenged Merck for patent infringement, and the US Court of Appeals voted that Merck did infringe on the patent. Because of this patent infringement, Merck will lose the rights for an exclusive patent to Fosamax in February 2008, when it was initially set to expire in February 2018. This will not have an effect on the probability of Merck winning cases concerning Vioxx, but will be used as a proxy to estimate the profit loss from Vioxx's expected sales.

Table 4.6 – First three events, the stock price change when the event occurs (the other cases are found in the appendix B table B2-1):

	Withdraw of Vioxx	*The Wall Street Jorunal* Report	US Court of Appeals ruling
Event #	One	Two	Three
Date	9/29/2004	10/29/2004	1/27/2005
	9/30/2004	11/1/2004	1/28/2005
Company	%Δ	%Δ	%Δ
Merck & Co	-26.80%	-9.70%	-10.10%
Pfizer, Inc	1.40%	-0.50%	-1.30%
Johnson & Johnson	-1.20%	0.10%	0.60%
GlaxoSmithKline plc Adr	-0.30%	1.70%	-0.50%
Sanofi-Aventis Ads	0.30%	0.10%	-0.10%
Amgen Inc	-2.00%	-2.00%	-0.50%
AstraZeneca Ads	-0.30%	0.00%	1.10%
Abbott Laboratories	0.10%	0.30%	-0.40%
Wyeth	-0.80%	0.50%	0.70%
Lilly (eli)	-2.90%	0.40%	-3.60%
Bristol-Myers Squibb	-0.80%	-0.30%	-2.60%
Schering-Plough	3.00%	-2.70%	-0.70%
Teva Pharm Indus Adr	-2.00%	-3.30%	2.20%
Forest Labs	0.20%	-1.10%	-1.90%
King Pharmaceuticals	-1.60%	-2.80%	0.80%

The last event (event four) was on February 18, 2005 when a FDA panel voted to allow sales of Cox-2 inhibitors, despite their increased risk of cardiovascular events. This panel voted in favor of Celebrex (31-1), Bextra (17-13), and Vioxx (17-15). This, the fourth event, will have a direct effect on the market's expectations of Merck's ability to win lawsuits as they will now be expected to win more cases since the FDA supports the sale of their drug. Merck increased 13 percent during the day of this announcement.

Table 4.7 – Fourth event and the first two court battles, the stock price change when the event occurs (the other cases are found in the appendix B table B2-2):

	FDA announces support for Cox-2 inhibitors	Merck loses case on Aug. 19, 2005	Merck wins case Nov. 3, 2005
Event #	Four		
Date	2/17/2005	8/18/2005	11/2/2005
	2/18/2005	8/19/2005	11/3/2005
Company	%Δ	%Δ	%Δ
Merck & Co	13.00%	-7.70%	3.80%
Pfizer, Inc	6.90%	-1.30%	1.30%
Johnson & Johnson	0.10%	-1.10%	-0.20%
GlaxoSmithKline plc Adr	0.90%	-0.20%	0.90%
Sanofi-Aventis Ads	2.50%	2.00%	0.40%
Amgen Inc	-0.60%	0.10%	4.90%
AstraZeneca Ads	1.70%	-1.20%	0.70%
Abbott Laboratories	-0.30%	-0.40%	0.40%
Wyeth	1.40%	-0.50%	1.40%
Lilly (eli)	-1.00%	0.10%	0.50%
Bristol-Myers Squibb	1.80%	-0.80%	0.70%
Schering-Plough	1.10%	-0.90%	0.10%
Teva Pharm Indus Adr	1.80%	-0.30%	1.50%
Forest Labs	1.50%	1.40%	0.70%
King Pharmaceuticals	1.70%	-0.70%	0.20%

Other events that are not analyzed under the event-study format, but are still relevant, are the first two cases heard against Merck. Merck lost the first case on August 19, 2005, but won their case on November 3, 2005 (later overturned). When Merck lost their first case, the court ruled that Merck had to pay a substantial amount of money. This signals to the market Merck's total cost of all cases to be heard causing the market to believe the total

cost of cases will increase. This results in a decrease of $5.1 billion in market capitalization. Merck's winning case in November (later overturned) was the first example that Merck could win a case and increased the market capitalization of Merck by $2.3 billion. The changes in market capitalization of all stocks during these events are shown below.

Table 4.8 -- The first three events, market capitalization change during event (all cases that have been decided by August 17, 2006 are included in the appendix B as table B3-1)

One-day change in Market Capitalization (Billions of Dollars) Company	Shares Outstanding In Billions	Withdraw of Vioxx	*The Wall Street Jorunal* Report	US Court of Appeals ruling
		9/29/2004	10/29/2004	1/28/2005
		9/30/2004	11/1/2004	1/28/2005
Merck & Co	2.19	-26.78	-6.72	-7.01
Pfizer, Inc	7.36	3.17	-1.13	-2.49
Johnson & Johnson	2.98	-2.08	0.18	1.19
GlaxoSmithKline plc Adr	2.91	-0.32	2.04	-0.7
Sanofi-Aventis Ads	2.71	0.3	0.05	-0.14
Amgen Inc	1.23	-1.5	-1.44	-0.35
AstraZeneca Ads	1.61	-0.23	-0.03	0.64
Abbott Laboratories	1.54	0.08	0.17	-0.3
Wyeth	1.34	-0.43	0.27	0.41
Lilly (eli)	1.14	-2.04	0.27	-2.25
Bristol-Myers Squibb	1.96	-0.37	-0.14	-1.23
Schering-Plough	1.48	0.82	-0.71	-0.19
Teva Pharm Indus Adr	0.62	-0.24	-0.38	0.27
Forest Labs	0.33	0.04	-0.19	-0.29
King Pharmaceuticals	0.24	-0.05	-0.07	0.02
Sum:		-29.61	-7.83	-12.4

Table 4.9 – Fourth event and the first two cases, market capitalization change during event (all cases that have been decided by August 17, 2006 are included in the appendix B as table B3-2)

One-day change in Market Capitalization (Billions of Dollars) Company	Shares Outstanding In Billions	FDA announces support for Cox-2 inhibitors	Merck loses case on Aug. 19, 2005	Merck wins case Nov. 3, 2005
		2/18/2005	8/19/2005	11/2/2005
		2/18/2005	8/19/2005	11/3/2005
Merck & Co	2.19	8.34	-5.14	2.34
Pfizer, Inc	7.36	13.1	-2.43	1.99
Johnson & Johnson	2.98	0.24	-2.02	-0.3
GlaxoSmithKline plc Adr	2.91	1.25	-0.23	1.37
Sanofi-Aventis Ads	2.71	2.52	2.28	0.38
Amgen Inc	1.23	-0.44	0.11	4.45
AstraZeneca Ads	1.61	1.05	-0.92	0.53
Abbott Laboratories	1.54	-0.25	-0.29	0.23
Wyeth	1.34	0.76	-0.28	0.85
Lilly (eli)	1.14	-0.6	0.06	0.3
Bristol-Myers Squibb	1.96	0.86	-0.39	0.29
Schering-Plough	1.48	0.31	-0.28	0.03
Teva Pharm Indus Adr	0.62	0.22	-0.06	0.37
Forest Labs	0.33	0.24	0.19	0.09
King Pharmaceuticals	0.24	0.04	-0.02	0.01
Sum:		27.63	-9.44	12.92

The second event increased Merck's aggregate amount lost to $33.5 billion, while the FDA panel vote decreased the total amount back to $25.2 billion. When Merck lost their case in Texas, the total amount increased again, this time to $30.3 billion, and Merck's victory decreased the aggregate loss to $28 billion. Because event three did not have a direct effect on the Vioxx lawsuits, the $7 billion lost that day was not seen as part of the

aggregate loss, but rather a reflection of the present discounted value of a Merck Patent loss of ten years.

All of the events in the event study show that Merck moves significantly when the event is included, but insignificantly when the event is not included. The coefficients on the dummy variables for events two through four can be found in appendix B as tables B2 through B4.

Merck lost $7 billion when the patent life on Fosamax was decreased, which represents the loss in expected profits by Merck over the additional ten years of expected patent protection. The drug industry lost a total of $12.4 billion, thus the remaining $5.4 billion loss that day represents the fears that other companies could also face these same patent issues on their profit-making drugs.

On August 19, 2005, plaintiff Carol Ernst won her lawsuit in the Texas Superior Court in Angleton, Texas (30 miles from Houston). Her lawsuit blamed Vioxx for the 2001 death of her husband, Robert Ernst, a 59-year-old marathon runner and Wal-Mart worker who was taking the arthritis painkiller at the time of his death. Mr. Ernst died of a heart attack, and the verdict held Merck liable for the death. Jurors voted 10-2 in favor of Ernst. The jury awarded more than $250 million in total damages: $24 million for mental anguish and loss of companionship and $229 million in punitive damages; although, Texas state law limits the amount of punitive damages to two million dollars when and if the case is upheld through the appeals process. Ernst's Houston-based lawyer, Mark

Lanier, said the punitive-damages figure was based on "the money Merck made and saved by putting off their product label changes."

CHAPTER FIVE
PATENT LOSS

When Merck withdrew Vioxx from the market in 2004, it was selling $2.5 billion a year world wide. The patent on Vioxx was set to expire on December 24, 2013, giving it about nine more years on patent at the time it was removed from the market. This represents nine years of profits, along with any additional sales that could have been made after the patent expired.

The third event in the study showed that the market efficiently reflected the lost value to Merck when the patent of Fosamax[16] was set to expire in February 2008, instead of when it was originally set to expire in February 2018.[17] This decision was made by the US Court of Appeals on January 28, 2005.

[16] More information about the drug Fosamax can be found in Appendix E.

[17] This is not actually a loss of patent to Merck, but rather a patent that is "…unenforceable due to findings of invalidity. Merck did not lose 10 years of patent term, regarding the one weekly dosing of Fosamax, rather, their patent was held to be invalid over a prior art reference (that means they cannot exclude others from making, selling or using the subject matter of the patent claims…)." Email correspondence from the USPTO (Mary Till) July 13, 2006. More information about the USPTO can be found in Appendix F.

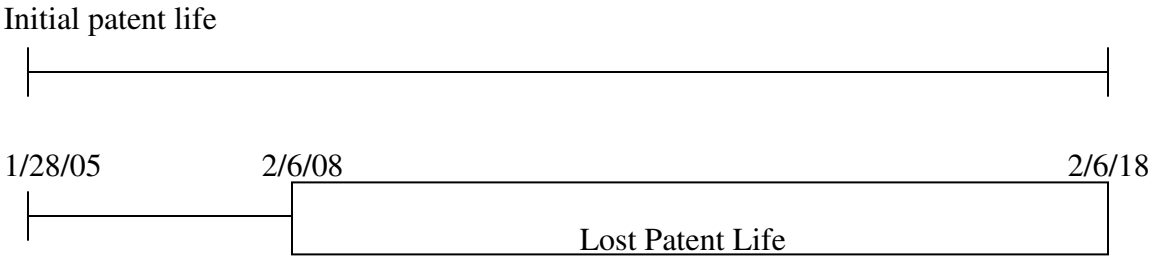


Figure 5.1 Fosamax Patent Loss

The gap between the initial patent life and the new patent life left Merck with a $7 billion loss on January 28, 2005. This means the market value of the last ten years of Merck's patent on Fosamax is $7 billion (b). With the years lost in patent and current sales of the drug, an internal rate of return (IRR) can be calculated. To find the IRR, I solve:

$$7\ b = \Sigma^{13}_{0=i} \left(\text{Sales} / (1 + r)^i \right) - \Sigma^{3}_{0=i} \left(\text{Sales} / (1 + r)^i \right) \qquad (1)$$

Where sales will be the sales of the drug expected during that year. In order to solve for r, which will give the IRR, I have to assume what sales will be. In "Safety, Patent Issues Weigh on Big Pharma" published in Forbes by Peter Kang on January 28, 2005, the sales of Fosamax were expected to be $3.6 billion. The sales in 2005 were actually $3.2 billion, but the day the event occurred, the market expectation was $3.6 billion. Although the expected sales are $3.6 billion dollars, the market only reacts to profits from sales.

In 2005, Merck's gross margin on sales was 76%, which means that of the $3.6 billion dollars of sales, $2.7 billion is the approximate profit margin:

$$7\ b = \Sigma^{13}_{0=i} \left(2.7\ b / (1 + r)^i \right) - \Sigma^{3}_{0=i} \left(2.7\ b / (1 + r)^i \right) \qquad (2)$$

Although Merck will lose the patent rights on Fosamax, this does not mean they will not be able to sell any. This means that they will have some reduced sales of the drug after the patent expires. Many studies have been conducted to examine what happens to the price of a drug when its patent expires. Because price can change in any direction—up, down, or remain constant—it is the remaining market share of the drug that reveals more information. Studies by Grabowski and Vernon (1992) and Caves, Whinston, and Hurwitz (1991) show that in the first year of patent loss a drugs market share will decrease by 20 to 30 percent. The following year's market share falls by 30 to 50 percent, and by the third year out, it will have lost a total of 80 percent of its market share. It is also important to know that the number of generics need to be large (more than 5), for this to occur. But at sales of $3.2 billion in 2005, ranking it in the top 20 for total sales,[18] I feel it safe to say that generics will be entering the market as soon as the patent expires.[19] These additional sales off-patent were to occur after the initial patent loss in 2018, but will now occur after the new patent expire date of 2008.

[18] This is using the sales of Fosamax in the United States in 2004, Fosamax was 20th with 1.9 billion dollars of sales in 2004 (found at Rxlist.com, $1.9 billion is the Weighted Average Cost times number of prescriptions).

[19] Since then Fosamax has been linked to a very rare jaw disorder that can cause the jaw to shatter. This information was not known at the time of the patent loss thus should have no effect on my estimates.

Thus (simplified because beyond year 15 they will both be discounting 80 percent of the sales and thus will cancel each-other out):

$$7\,b = \Sigma^{13}_{0=i}\left(2.7\,b / (1+r)^{i}\right) + \left(2.7\,b * .75 / (1+r)^{14}\right) + \left(2.7\,b * .6 / (1+r)^{15}\right)) - \Sigma^{3}_{0=i}\left(2.7\,b / (1+r)^{i}\right) + \left(2.7\,b * .75 / (1+r)^{4}\right) + \left(2.7\,b * .6 / (1+r)^{5} + \Sigma^{15}_{6=i}\left(2.7\,b * .2 / (1+r)^{i}\right)\right) \quad (3)$$

Here I find an IRR of 13.2 percent (11.7 percent when using the gross profit margin on $3.2 billion). I use this as an estimated market IRR for Merck, not the specific drug but the company itself. This IRR can now be used to estimate Merck's lost profits when Vioxx was withdrawn from the shelves.[20]

Using the IRR, it is now possible to see what the loss in profits was for Vioxx, which sold $2.5 billion the year before it was removed from the market.[21] The Vioxx patent was set to expire in December of 2013. Merck's gross margin during the last year Vioxx was still sold (2003), was 80 percent meaning that the $2.5 billion in sales is $2 billion in profits:

$$\Sigma^{9}_{0=i}\left(2\,b / (1+.132)^{i}\right) + \left(2\,b * .75 / (1+.132)^{10}\right) + \left(2\,b * .6 / (1+.132)^{11}\right) + \Sigma^{\infty}_{12=i}\left(2\,b * .2 / (1+.132)^{i}\right) = 11.5\,b \quad (4)$$

Thus the total loss of profits to Merck from the withdrawal of Vioxx is $11.5 billion.[22]

[20] With Vioxx's sales of $2.5 billion it is safe to assume that it also would have had sufficient generic entry (in 2004 U. S. sales of Vioxx were ranked 37th).
[21] It is valuable to note that both these drugs are developed for the same demographics, primarily older people, along with the fact that they both seemed to have hit a plateau in terms of sales.
[22] Vioxx had 9 years and 3 months of patent remaining, the 3 months was controlled for when solving.

Sensitivity of Fosamax patent loss

When Merck lost ten patent years from their drug Fosamax, the market cap decreased by $7 billion. This loss is due to their loss in the patent, but the loss in profits may be more than the $7 billion if the expected probability of Merck losing this case was greater than zero. Because of this, I look at the value of the loss in patent for variations in the probability of Merck's victory in this case.

As the expected probability of victory (of this case) falls, the amount lost due to the expected profits on Fosamax increases:

Probability of Victory * Expected Loss = Change in Market Capitalization

$$\Pr(\text{win}) * E(\text{loss}) = \Delta \text{ Mkt. Cap}$$

$$1 * \$7\text{ b} = \$\ 7\text{b}$$

So for the $7 billion loss the day the USPTO ruled against Merck for the loss of ten years of their patent on Fosamax, the expectations of Merck's victory in this case would have had to have been 100 percent. It is reasonable to believe that some investors believed that Merck could lose, so to look at the effects of the probability of victory on the payout, I will change the probability to see how this reflects losses in Merck's market capitalization for this event.

If the expected probability of victory decreased to 90 percent:

$$\Pr(\text{win}) * E(\text{loss}) = \Delta \text{ Mkt. Cap}$$

$$.9 * \$7.78 \text{ b} = \$ 7\text{b}$$

This shows that when the expected probability of victory goes down, the expected loss in Merck, due to the lost patent, increases. If the expected probability at the time of the announcement was actually 90 percent, instead of 100 percent, the total loss due to the patent is $7.78 billion. This $7.78 billion would show up as $7 billion at the announcement because part of the adjustment was already made in the expectations of the outcome.

Table 5.1 – Sensitivity test for Merck's probability of victory on Fosamax patent case:

Expected Probability of Victory	Actual Patent loss Valuation	Change the day of announcement
100%	7.01	7.01
90%	7.79	7.01
80%	8.76	7.01
70%	10.01	7.01
60%	11.68	7.01
50%	14.02	7.01
40%	17.53	7.01
30%	23.37	7.01

The actual loss and change the day of announcement are in billions of dollars

As you can see, as the expected probability of victory falls, the actual amount lost due to the loss in patent increases. To see how this changes the IRR and the expected loss in profits to Vioxx, see table 5.2 below:

Table 5.2 – Sensitivity test for Merck's probability of victory on Fosamax patent case:

Expected Probability of Victory	Value of Patent	IRR	Loss to Vioxx
100	7.01	13.24%	11.48
90	7.79	11.87%	12.31
80	8.76	10.38%	13.37
75	9.33	9.6%*	14.01
70	10.01	8.74%	14.80
60	11.68	6.90%	16.94
50	14.02	4.80%	20.70
42.58	16.44	3.03%**	26.78
40	17.53	2.34%	31.26
30	23.37	-0.67%	

* - CAPM estimate of IRR for Merck

** - IRR that shows all lose the day of the withdrawal is due to lost profits from Vioxx

Using the CAPM framework to get that the expected probability of victory was 75 percent and not 100 percent, the loss of profits due to the withdrawal of Vioxx was $14.01 billion.

Because it is unknown what the actual probability of Merck winning this case was, I used $7 billion. This case was an appeal from lower court cases in which Merck had won the lower court decision.

CHAPTER SIX
PROBABILITY OF MERCK VICTORY

The market value (MV) is equal to the discounted expected future cash flows (Ç) of a company.

$$MV = \Sigma^{\infty}_{t=0} Ç_t \quad (5)$$

When a recall occurs, there is a direct cost (θ) of the recall. Thus,

$$MV = \Sigma^{\infty}_{t=0} Ç_t - \theta \quad (6)$$

so the direct costs will be taken from the value of the firm. These direct costs, according to Merck's 2005 Annual Report's financial section, will be the costs of recalling the previously sold products ($491.6 million), loss of current inventory ($93.2 million), and the costs to undertake the withdrawal ($141.4 million). This leaves the total direct cost of recall at $726.2 million, which is $552.6 million post tax.[23] Because I cannot find the markets estimate of this θ the day the announcement was made, I will assume the market's estimation was close to the after-tax cost of the recall, or $552.6 million.

The recall will not only entail the direct costs of the recall, but the legal costs of lawsuits that will follow. The first of the legal costs are the fixed legal costs (ρ). Fixed legal costs would be the initial gathering of the data to support their case, along with gathering a

[23] From Merck's 2005 annual report.

legal team to do the proceedings. There will also be a marginal cost of litigation (φ),[24] which will be the lawyer and any other marginal costs representing the firm at each court case, times the number of cases heard (σ).

$$MV = \Sigma^{\infty}_{t=0} Ç_t - \theta - \rho - (\varphi * \sigma) \quad (7)$$

The additional, and arguably largest, cost of the recall will be the expected payout for all cases lost. The expected total payout from litigation will also be encompassed in the market value. This expected total payout will be the payout awarded for any given litigation (ξ) multiplied by the number of cases (δ) and the probability of losing each individual case (γ).[25]

$$E\,[\text{total payout}] = \xi * \delta * \gamma \quad (8)$$

This gives a total market value when the recall occurs:

$$MV = \Sigma^{\infty}_{t=0} Ç_t - \theta - \rho - (\varphi * \sigma) - E\,[\text{total payout}] \quad (9)$$

or

$$MV = \Sigma^{\infty}_{t=0} Ç_t - \theta - \rho - (\varphi * \sigma) - (\xi * \delta * \gamma)$$

Merck also loses its ability to sell Vioxx, both under patent and after patent expiry. This means that the expected profits ($E[\pi]$) will also have to be taken out of the market value.

$$MV = \Sigma^{\infty}_{t=0} Ç_t - \theta - \rho - (\varphi * \sigma) - (\xi * \delta * \gamma) - E[\pi] \quad (10)$$

[24] The cost will be for the litigation for each lawsuit because markets react negatively to companies that settle rather then taking it to court. This and Merck's stated confidence in their ability to win cases causes me to assume that all cases that are filed will go to trial.

[25] The probability of loss is used here because Merck will only have to pay a plaintiff (PŁ) if Merck loses the case.

To determine the change on the market value I can subtract the market value of the firm after the recall (MV_a) from the market value of the firm before the recall was announced (MV_b). Thus the change in the market value (Δ MV) is:

$$\Delta \text{ MV} = MV_b - MV_a$$

or

$$\Delta \text{ MV} = (\Sigma^{\infty}_{t=0} \text{Ç}_t) - (\Sigma^{\infty}_{t=0} \text{Ç}_t - \theta - \rho - (\varphi * \sigma) - (\xi * \delta * \gamma) - E[\pi])$$

$$= \theta + \rho + (\varphi * \sigma) + (\xi * \delta * \gamma) + E[\pi] \qquad (11)$$

To find the probability of Merck winning cases (ω), I must first find γ then subtract it from one.

$$\omega = 1 - \gamma \qquad (12)$$

The significant change in market value (Δ MV) was \$26.8 billion the day Merck recalled Vioxx. In addition, the direct costs were \$552.6 million (m) and the total loss in profits was \$11.48 billion, based on estimates from the previous patent loss section.

$$26.8 \text{ b} = 552.6 \text{ m} + \rho + (\varphi * \sigma) + (\xi * \delta * \gamma) + 11.5 \text{ b} \qquad (13)$$

Thus,

$$14.73 \text{ b} = \rho + (\varphi * \sigma) + (\xi * \delta * \gamma)$$

At the time of the withdrawal, it was estimated that Merck would have to face nearly 10,000 cases.

$$14.73 \text{ b} = \rho + (\varphi * \sigma) + (\gamma * 10{,}000 * \xi) \qquad (14)$$

Merck established approximately $675 million[26] in reserve to cover the initial and future legal costs over Vioxx (later increased by $295 million, but this was after the time of the withdrawal). I assume that this is an accurate, and known, estimate at the time of the removal.

[26] December 15, 2006: Merck has set aside $1.6 billion to cover litigation costs and nothing for liability.

As Merck increases the funds to cover the marginal cost of cases, each dollar they increase it covers more cases then it did before.

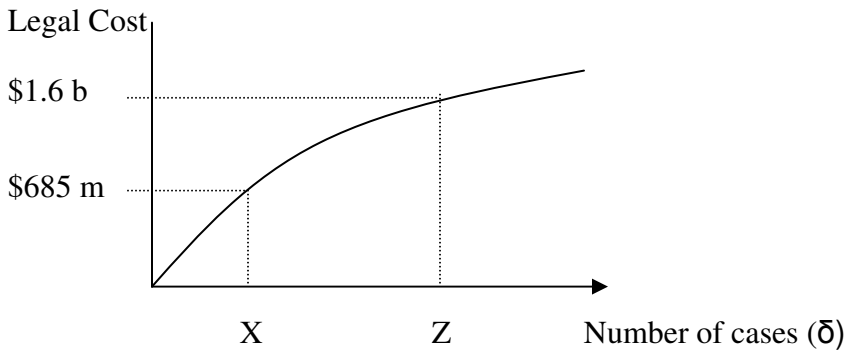


Figure 6.1 Legal Cost Per Case

Where $X < (Z - X)$, showing that as Merck increases the amount set aside for legal costs, doubling the money will cover more then double the cases. The initial legal cost is then $675 million, which will include the legal cost and the marginal cost of the cases they expect to go to trial. This number will grow over time. After the first three cases were heard, this number increased to $685 million, so $X = 3$, and the total cases heard when Merck increased this number to $1.6 billion was 13 ($Z = 13$) — ten additional cases for the additional $915 million dollars ($Z - X = 10$). Because this goes up over time, the average increase in this number over a year is accounted for when solving for the probability of a case after more money is put into this account.

$$\rho + (\varphi * \sigma) = 675 \text{ m}$$

So

$$14.73 \text{ b} = 675 \text{ m} + (\xi * 10{,}000 * \gamma)$$

or

$$14.05\ b = (\xi * 10{,}000 * \gamma)$$

If the average litigation payout, ξ, is \$5 million,[27] then

$$14.05\ b = (5\ m * 10{,}000 * \gamma) \qquad (15)$$

$$14.05\ b / (5\ m * 10{,}000) = \gamma$$

$$28.1 = \gamma$$

$$\omega = 1 - 28.1 = 71.9$$

Using these assumptions, Merck's probability of loss is 28.1 percent, making the probability that Merck will win a case 71.9 percent.

Because the expected payout per case can vary depending on who you ask, what I will look at is the relative probability change. This will work because as long as the expected payout used remains constant, this relative change will hold (using mid point formula). This uses the value found in equation 15, but adds the additional amount lost at any given event.

[27] I used \$5 million as the expected payout. This number can be debated greatly, and it is hard to tell what the expected payout would be per case when this event occurred. However, because I use the relative probability change as each event occurs, this payout will only affect the initial starting point. Of the \$14.05 billion loss, Merck's financial statements indicate that they will lose \$3 billion in 'goodwill' (brand name capital), this would increase the initial probability of success to 77.9 percent.

After *The Wall Street Journal* announced that Merck executives knew about the increased cardiovascular events in the mid-to-late 1990's their probability of successful litigation decreased by 18.7 percent. But when the FDA announced its support of Cox-2 inhibitors, despite their increased heart risk, Merck's probability of success increased by 28.5 percent. Merck lost their first case when a Texas jury voted 10-2 in favor of the plaintiff. This caused the market value of Merck to fall by $5.1 billion, which caused their probability of success to decrease by 13.4 percent. After each case, the probability of victory for Merck was: second case (7.5%), third (-4.2%), fourth (-2.7%), fifth (3.7%), sixth (-1.4%), seventh (1.8%), eighth (1.6%), and ninth (-14.6%).[28]

[28] It is also important to note that since this ruling, the judge threw out the $51 million as "excessive" pay. The amount Merck will have to pay is still not known.

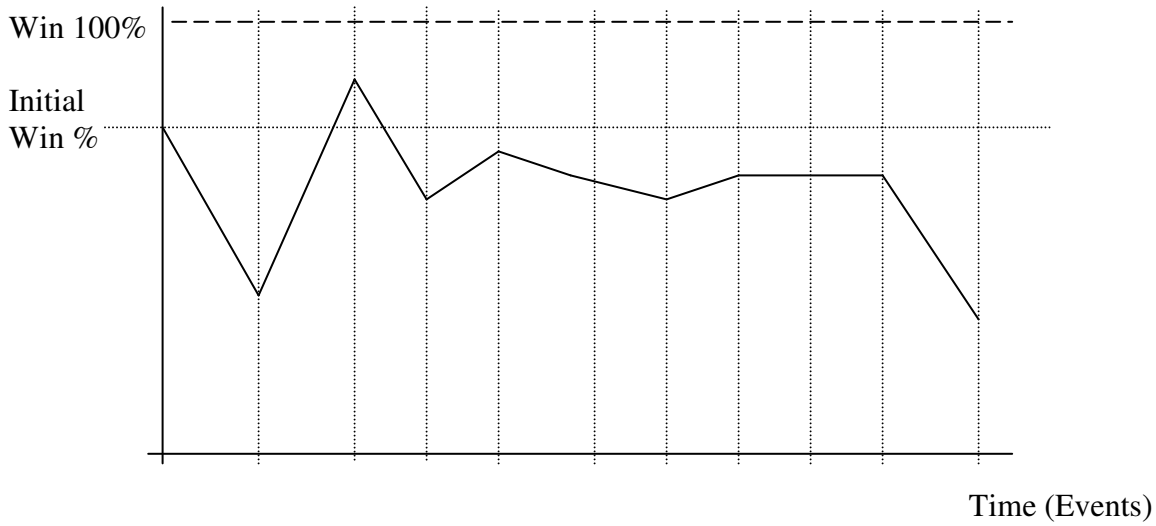


Figure 6.2 Expected Probability of Merck Victory

Table 6.1 – What happens when the assumptions change?

		Sensitivity		
	Baseline	Δ E[π]	Δ Legal Cost	Δ Payout
ω	71.9%	76.9%	73.7%	85.90%
E[π]	$11.5 billion	$14.01 billion	$11.5 billion	$11.5 billion
Legal Cost	$675 million	$675 million	$1.6 billion	$675 million
Payout	$5 million	$5 million	$5 million	$10 million

As you can see from table 6.1 above, the payout per case has the largest effect on changing the probability outcome.[29] The cases that have been heard are the cases that will most likely have the highest payouts, so I look at these cases as an upper bound estimate. Thus even though the average of the payouts seems high to this point, it makes sense to have the average expected payout to be lower than that level. For this reason, I also use the relative probability change; this will give an accurate estimate of the change in probability no matter what the starting expected probability is.

[29] The amount the probability will change can be found below in table 6.2.

Table 6.2 -- Probability outcomes as expected payout changes:

Expected Payout	Probability of Loss	Probability of Win
$3 million	47%	53%
$5 million	28%	72%
$10 million	14%	86%
$20 million	7%	93%

Should Merck have withdrawn when they did?

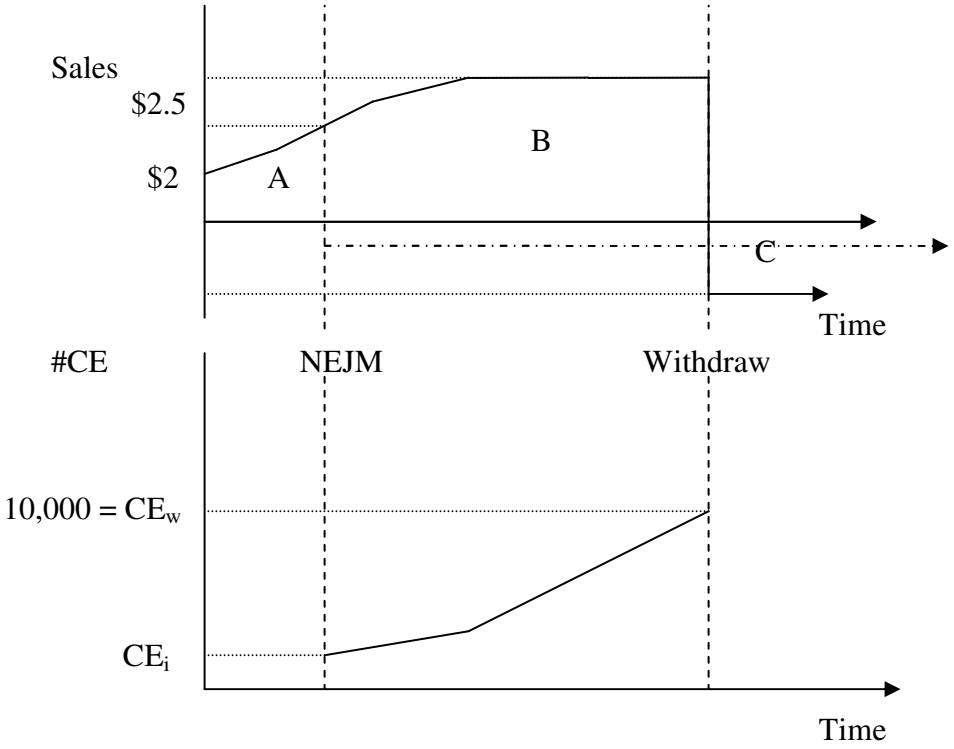


Figure 6.3 Timing of Withdrawal

Merck lost $26.8 billion from the announcement, and of that, $11.5 billion was a loss in expected profits. This left $15.3 billion dollars as the total cost of cases Merck was expected to face, while Merck was selling $2.5 billion dollars a year of the drug. Because I don't have the ability to adequately separate the $15.3 billion into what is a

loss in brand name capital and what are expected litigation costs, I can't find the exact amount of C, but I do know that the $15.3 is the combination of those two. If it was a good idea, then this should be smaller then area B. Here, area B is the total amount of sales from Vioxx from late 2000 until late 2004. Using the same internal rate of return solved for earlier (13.2 percent) to discount forward, the value of sales over that period the day of the withdrawal was $15.9 billion. That $15.9 billion is the amount made in sales, but the actual amount made in profits is $12.7 billion.

From this information Merck should have withdrawn the drug and written a rebuttal when the NEJM was published. For Merck to be indifferent between the early withdrawal and withdrawing in September 2004, Merck would have had to expect brand name capital to fall by at least $2.6 billion dollars from the early withdrawal.[30] Another reason that Merck would have been better off by keeping Vioxx on the market is that if the executives knew the withdrawal would have such an effect on stock price, they could use the currently inflated stock to acquire other companies. They could also use these inflated stocks for stock options that were immediately executable.

[30] It is equal to $6 billion at the withdrawal date, but discounted back to the NEJM is $4.7 billion. This could also encompass any expected legal cases if Merck would have had to battle them at that time.

CHAPTER SEVEN
CONCLUSIONS

Using an event-study format, I show that the market reacts immediately to all the events. With that information, I am able to calculate the loss to Merck by looking at their market capitalization change when any particular event occurs. Knowing that the market reacts immediately to information, we find that when Merck removed Vioxx from the shelves, it had a loss in market value of $26.8 billion. After *The Wall Street Journal* published an article stating that Merck executives knew since the mid-to-late 1990's that Vioxx increases the risk of cardiovascular events, the market value of Merck fell another $6.7 billion. This gave the company a total loss of $33.5 billion. When Merck initially withdrew Vioxx from the shelves, there was an expected probability of 72 percent that Merck would win a lawsuit filed against it, but when the information was released by *The Wall Street Journal*, their probability of winning a lawsuit decreased to around 59 percent.

More information was revealed when the FDA announced its support of Cox-2 inhibitors which decreased the total loss of Merck to $25.2 billion. However, they lost their first case in August of 2005 causing an additional loss to Merck's market capitalization of $5.1 billion, increasing the total loss to Merck to $30.3 billion. This changed Merck's chances of winning future cases, moving the final probability of winning any given case to 65 percent. As of August 17, 2006 (after the first nine cases were heard), the probability of Merck successfully defending its cases is 59 percent.

Although the loss in market capitalization is large, the expected loss to the company is not entirely due to legal issues. When Merck removed Vioxx from the shelves it eliminated its third largest drug from the market, at $2.5 billion a year. So in removing Vioxx from sale, it also took away a large profit-making drug from the company. To find the loss in value to the company due to profit loss, I use the drug Fosamax to find an internal rate of return for the company. I find that the market gives a 13.2 percent internal rate of return to Merck's drugs, allowing an estimation of profit loss from the removal of Vioxx to reach $11.5 billion.

With this information, we can observe how the market reflects the change in the probability of Merck winning cases. I also find that Merck's decision to withdraw in September 2004, rather than 2000, seems to have been (ex-post) a questionable decision. Because of the lag in information from the drug industry, this also signals that Merck did not know of the risks of Vioxx before the withdrawal. If they did know how substandard the drug was, they would have withdrawn it at an earlier date.

Future studies in this area will explore how long it takes, or how many cases have to he heard, for the market to find a stable probability of Merck's success as well as litigation outcomes over time. Future research will continue to look at this recall information, at Merck and at other companies that deal with the recall decision, to analyze an incentive mis-alignment, socially tolerable risk, and ways to find accurate estimates of the losses.

APPENDICES

Appendix A

Merck Charts

Figure A1
Merck chart from Aug. 23, 2004 to Aug 23, 2006 (from bigcharts.com).

Figure A2
Merck's daily returns from August 17, 2004 to August 17, 2006.

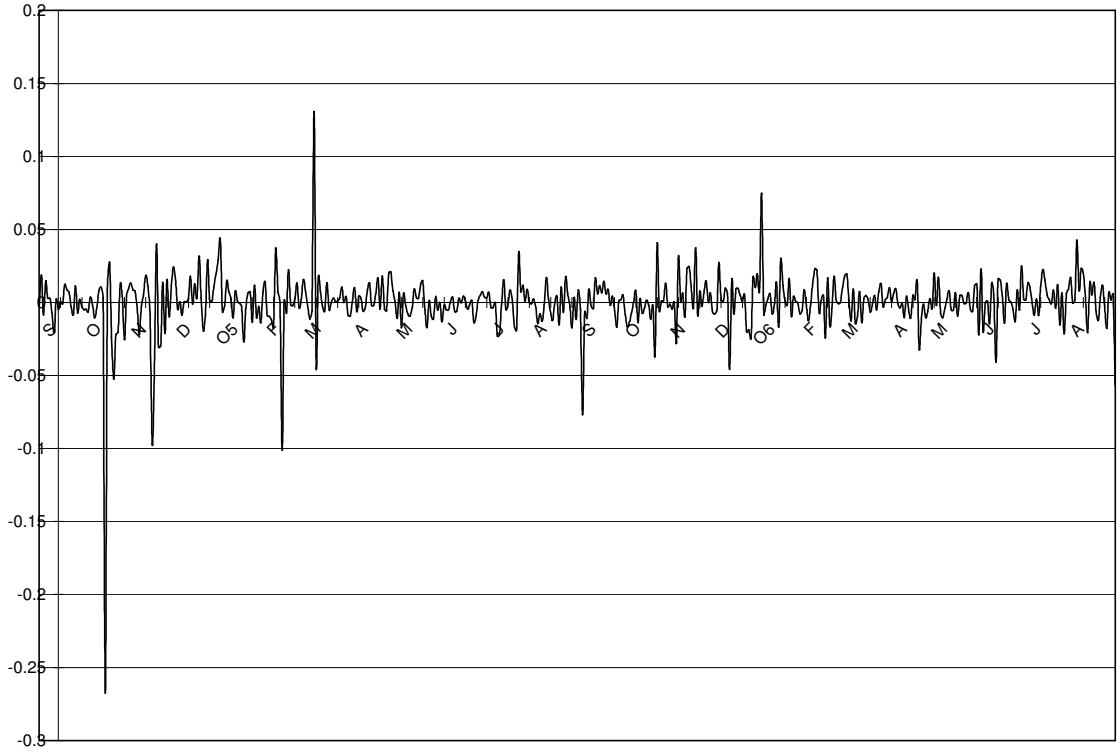
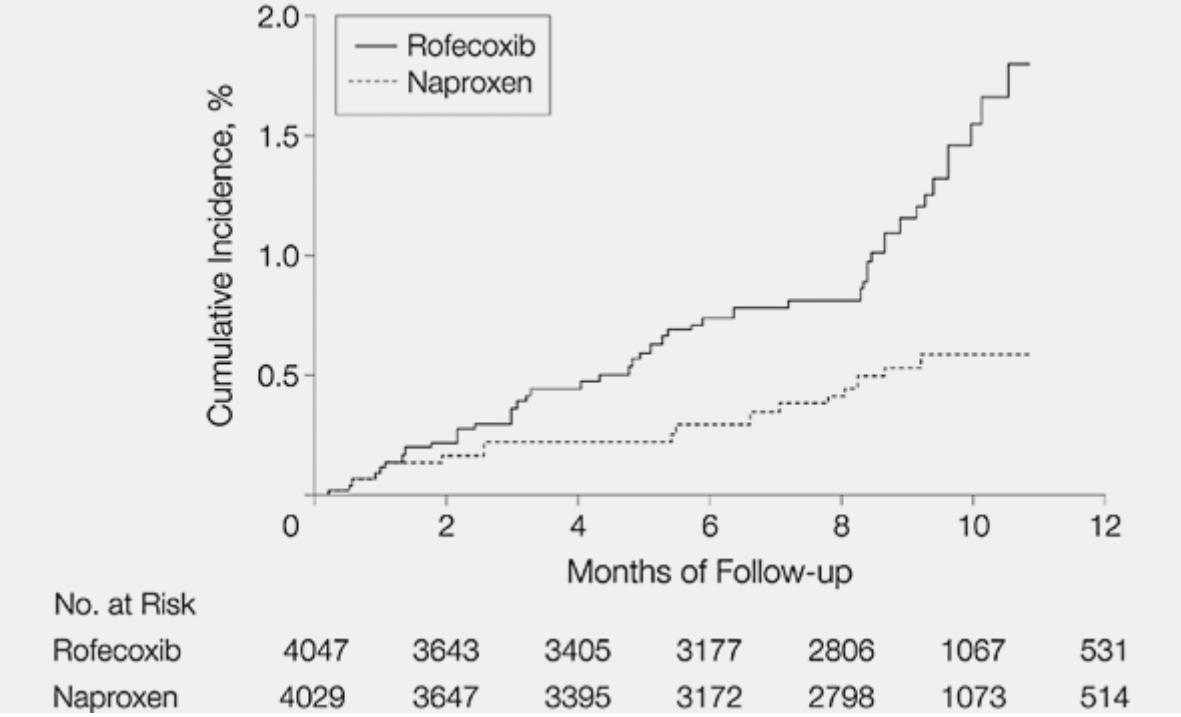


Figure A3
Time to Cardiovascular Adverse Event in the VIGOR Trial



This figure is from figure 1 in the paper "Risk of Cardiovascular Events Associated With Selective COX-2 Inhibitors" by Mukherjee, Nissen, and Topol published in *Journal of the American Medical Association*, August 22/29, 2001 - Vol 286, No. 8 located on page 956.

Appendix B

Other Event-Studies

Table B1-4
Event One, three-day event study before event, including event day and without event day: September 30, 2004:

Company	Mrkonebef (Before Event One With Day)		Mrkonebefwoday (Before Event One Without day)	
	VWI	S&P	VWI	S&P
Merck & Co	-0.087 (8.37)**	-0.087 (8.38)**	0.008 (0.68)	0.007 (0.68)
Pfizer, Inc	0.008 (1.15)	0.008 (1.23)	0.005 (0.75)	0.005 (0.75)
Johnson & Johnson	-0.003 (0.71)	-0.003 (0.7)	0.002 (0.37)	0.002 (0.36)
GlaxoSmithKline plc Adr	0.005 (0.78)	0.005 (0.83)	0.005 (0.87)	0.005 (0.87)
Sanofi-Aventis Ads	0.01 (1.27)	0.01 (1.32)	0.014 (1.8)	0.014 (1.8)
Amgen Inc	-0.003 (0.4)	-0.003 (0.33)	0.004 (0.45)	0.003 (0.44)
AstraZeneca Ads	-0.008 (1.05)	-0.008 (1.01)	-0.009 (1.18)	-0.009 (1.19)
Abbott Laboratories	-0.003 (0.54)	-0.003 (0.49)	-0.001 (0.19)	-0.001 (0.2)
Wyeth	-0.001 (0.09)	0 (0.04)	-0.001 (0.14)	-0.001 (0.15)
Lilly (eli)	-0.019 (2.53)*	-0.018 (2.49)*	-0.01 (1.42)	-0.011 (1.45)
Bristol-Myers Squibb	-0.001 (0.15)	0 (0.07)	-0.001 (0.26)	-0.002 (0.28)
Schering-Plough	0.005 (0.58)	0.005 (0.64)	-0.005 (0.6)	-0.005 (0.61)
Teva Pharm Indus Adr	-0.009 (1.01)	-0.008 (0.93)	-0.009 (1.03)	-0.009 (1.04)
Forest Labs	0.004 (0.37)	0.005 (0.41)	0 (0.03)	0 (0.02)
King Pharmaceuticals	-0.007 (0.43)	-0.006 (0.41)	-0.005 (0.31)	-0.005 (0.32)

* significant at 5%; ** significant at 1%, Absolute value of t statistics in parentheses

Table B1-5
Event One, month after event and three months after event: September 30, 2004

Company	Monthafterone (Event One Month After)		Mrkthreemonone (Event One Three Months After)	
	VWI	S&P	VWI	S&P
Merck & Co	-0.002	-0.002	0	0
	(0.4)	(0.41)	(0.11)	(0.12)
Pfizer, Inc	-0.003	-0.003	-0.003	-0.003
	(0.97)	(1)	(1.64)	(1.66)
Johnson & Johnson	0.001	0.001	0.001	0.001
	(0.58)	(0.58)	(0.93)	(0.93)
GlaxoSmithKline plc Adr	-0.002	-0.002	0	0.001
	(0.94)	(0.94)	(0.35)	(0.37)
Sanofi-Aventis Ads	-0.001	-0.001	0	0
	(0.35)	(0.34)	(0.08)	(0.11)
Amgen Inc	-0.001	-0.001	0.001	0.001
	(0.23)	(0.23)	(0.31)	(0.35)
AstraZeneca Ads	0	0	-0.003	-0.003
	(0.12)	(0.12)	(1.7)	(1.68)
Abbott Laboratories	0	0	0.001	0.001
	(0.08)	(0.08)	(0.59)	(0.62)
Wyeth	0.003	0.003	0.001	0.002
	(0.88)	(0.89)	(0.83)	(0.85)
Lilly (eli)	-0.004	-0.004	-0.002	-0.002
	(1.54)	(1.56)	(1.01)	(1)
Bristol-Myers Squibb	-0.001	-0.001	0	0.001
	(0.35)	(0.36)	(0.37)	(0.41)
Schering-Plough	-0.003	-0.003	0	0
	(1.13)	(1.14)	(0.02)	(0)
Teva Pharm Indus Adr	-0.001	-0.001	0.001	0.001
	(0.17)	(0.16)	(0.54)	(0.59)
Forest Labs	0	0	0	0
	(0.02)	(0.02)	(0.05)	(0.02)
King Pharmaceuticals	-0.005	-0.005	0	0
	(0.79)	(0.79)	(0.04)	(0.03)

* significant at 5%; ** significant at 1%, Absolute value of t statistics in parentheses

Table B1-6
Event One, month before event and three months before event: September 30, 2004

Company	Monthbeofreone (Event One Month Before)		Threemonbeofone (Event One Three Months Before)	
	VWI	S&P	VWI	S&P
Merck & Co	0.001 (0.27)	0.001 (0.32)	0.001 (0.36)	0.001 (0.37)
Pfizer, Inc	-0.004 (1.36)	-0.003 (1.28)	-0.001 (0.62)	-0.001 (0.63)
Johnson & Johnson	-0.001 (0.67)	-0.001 (0.6)	0 (0.43)	0.001 (0.46)
GlaxoSmithKline plc Adr	0.002 (0.97)	0.002 (1.03)	0.001 (0.45)	0.001 (0.44)
Sanofi-Aventis Ads	0.001 (0.26)	0.001 (0.32)	0.002 (1.15)	0.002 (1.14)
Amgen Inc	-0.002 (0.69)	-0.002 (0.59)	0.002 (0.96)	0.002 (0.96)
AstraZeneca Ads	-0.006 (1.95)	-0.005 (1.9)	-0.002 (0.99)	-0.002 (1)
Abbott Laboratories	0.001 (0.24)	0.001 (0.33)	0.001 (0.75)	0.001 (0.75)
Wyeth	0 (0.05)	0 (0.03)	0.001 (0.65)	0.001 (0.65)
Lilly (eli)	-0.002 (0.71)	-0.002 (0.63)	-0.002 (1.04)	-0.002 (1.05)
Bristol-Myers Squibb	0 (0.18)	0 (0.08)	0 (0.25)	0 (0.24)
Schering-Plough	-0.002 (0.8)	-0.002 (0.72)	0 (0.13)	0 (0.13)
Teva Pharm Indus Adr	-0.004 (1.13)	-0.003 (1.04)	-0.004 (1.86)	-0.004 (1.88)
Forest Labs	-0.002 (0.49)	-0.002 (0.45)	-0.003 (1.27)	-0.003 (1.28)
King Pharmaceuticals	-0.002 (0.41)	-0.002 (0.38)	0.002 (0.45)	0.002 (0.45)

* significant at 5%; ** significant at 1%, Absolute value of t statistics in parentheses

Table B2-1
Percent change during the listed events

	Mistrial declaired on Dec. 12, 2005	Merck wins case on Feb. 18, 2006	Merck splits cases on Apr. 5, 2006	Merck loses case on Apr. 21, 2006
	12/9/2005	2/17/2006	4/4/2006	4/20/2006
	12/10/2005	2/21/2006	4/5/2006	4/21/2006
Company	%Δ	%Δ	%Δ	%Δ
Merck & Co	2.53%	1.29%	-1.42%	0.75%
Pfizer, Inc	-1.62%	0.70%	-0.28%	0.32%
Johnson & Johnson	-0.07%	-0.12%	0.72%	-0.26%
GlaxoSmithKline plc Adr	-0.71%	0.41%	0.48%	0.25%
Sanofi-Aventis Ads	-1.18%	2.55%	0.81%	0.56%
Amgen Inc	1.19%	0.48%	-1.15%	2.53%
AstraZeneca Ads	-0.93%	-0.88%	-0.49%	-1.37%
Abbott Laboratories	-0.46%	0.80%	-0.16%	-0.21%
Wyeth	-0.09%	0.37%	1.47%	-1.54%
Lilly (eli)	-1.95%	0.61%	0.53%	1.30%
Bristol-Myers Squibb	0.42%	0.87%	0.86%	-0.44%
Schering-Plough	0.31%	0.16%	-0.21%	-1.27%
Teva Pharm Indus Adr	1.53%	1.32%	0.88%	0.53%
Forest Labs	-1.55%	1.71%	-0.45%	0.21%
King Pharmaceuticals	-1.86%	-0.05%	-0.97%	1.66%
Dow Jones Industrial Average	0.10%	0.42%	-0.32%	-0.04%
S & P 500 Index	-0.08%	0.33%	-0.43%	0.01%
AMEX pharmaceutical index	-0.40%	0.66%	0.15%	0.17%

Table B2-2
Percent change during the listed events

	Merck wins case on Jul. 13, 2006	Merck wins case Aug. 2, 2006	Merck loses case Aug. 17, 2006 (judge also throws out Merck's Nov '05 win)
	7/12/2006	8/1/2006	8/16/2006
	7/13/2006	8/2/2006	8/17/2006
Company	%Δ	%Δ	%Δ
Merck & Co	-0.65%	-0.51%	-5.71%
Pfizer, Inc	1.36%	1.48%	0.93%
Johnson & Johnson	0.58%	-0.74%	-0.59%
GlaxoSmithKline plc Adr	1.47%	1.82%	-1.37%
Sanofi-Aventis Ads	3.21%	0.94%	0.04%
Amgen Inc	0.93%	-1.00%	0.47%
AstraZeneca Ads	1.99%	0.37%	-0.94%
Abbott Laboratories	0.27%	0.76%	-0.30%
Wyeth	2.07%	0.04%	0.32%
Lilly (eli)	1.35%	-1.12%	0.70%
Bristol-Myers Squibb	1.21%	0.46%	1.90%
Schering-Plough	0.48%	0.05%	0.30%
Teva Pharm Indus Adr	3.64%	-1.96%	-0.37%
Forest Labs	0.42%	-0.19%	3.38%
King Pharmaceuticals	0.47%	0.23%	-0.97%
Dow Jones Industrial Average	1.54%	-0.66%	0.07%
S & P 500 Index	1.31%	-0.51%	0.16%
AMEX pharmaceutical index	1.32%	0.34%	-0.44%

Table B3-1
Total market capitalization change during the listed event:

	Mistrial declaired on Dec. 12, 2005	Merck wins case on Feb. 18, 2006	Merck splits cases on Apr. 5, 2006	Merck loses case on Apr. 21, 2006
	12/9/2005	2/17/2006	4/4/2006	4/20/2006
Company	12/12/2005	2/21/2006	4/5/2006	4/21/2006
Merck & Co	-1.57	-1.01	1.12	-0.57
Pfizer, Inc	2.5	-1.32	0.52	-0.59
Johnson & Johnson	0.12	0.21	-1.25	0.45
GlaxoSmithKline plc Adr	1.05	-0.61	-0.73	-0.38
Sanofi-Aventis Ads	1.36	-2.98	-1.03	-0.7
Amgen Inc	-1.14	-0.44	1.04	-2.09
AstraZeneca Ads	0.72	0.64	0.4	1.19
Abbott Laboratories	0.28	-0.54	0.11	0.14
Wyeth	0.05	-0.24	-0.95	0.98
Lilly (eli)	1.21	-0.39	-0.33	-0.78
Bristol-Myers Squibb	-0.18	-0.39	-0.41	0.22
Schering-Plough	-0.09	-0.04	0.06	0.37
Teva Pharm Indus Adr	-0.41	-0.33	-0.23	-0.13
Forest Labs	0.21	-0.26	0.07	-0.03
King Pharmaceuticals	0.07	0	0.04	-0.07
Sum:	4.18	-7.71	-1.59	-2

Table B3-2
Total market capitalization change during the listed event:

	Merck wins case on Jul. 13, 2006	Merck wins case Aug. 2, 2006	Merck loses case Aug. 17, 2006 (judge also throws out Merck's Nov '05 win)
	7/12/2006	8/1/2006	8/16/2006
Company	7/13/2006	8/2/2006	8/17/2006
Merck & Co	0.52	0.46	-5.14
Pfizer, Inc	-2.28	-2.8	1.84
Johnson & Johnson	-1.04	1.4	-1.13
GlaxoSmithKline plc Adr	-2.33	-2.85	-2.21
Sanofi-Aventis Ads	-4.17	-1.19	0.05
Amgen Inc	-0.75	0.88	0.38
AstraZeneca Ads	-1.87	-0.35	-0.95
Abbott Laboratories	-0.18	-0.55	-0.23
Wyeth	-1.2	-0.03	0.2
Lilly (eli)	-0.84	0.73	0.44
Bristol-Myers Squibb	-0.59	-0.22	0.78
Schering-Plough	-0.13	-0.01	0.09
Teva Pharm Indus Adr	-0.69	0.41	-0.08
Forest Labs	-0.05	0.03	0.52
King Pharmaceuticals	-0.02	-0.01	-0.04
Sum:	-15.62	-4.11	-5.47

Table B4-1
Event two's reaction to the market on November 1, 2004 (*The Wall Street Journal* Report):

Company	Mrktwo (1) VWI	Mrktwowoday (2) VWI	Monaftertwo (3) VWI
Merck & Co	-0.039 (3.50)**	-0.019 (1.73)	0 (0.11)
Pfizer, Inc	0.003 (0.44)	-0.003 (0.46)	-0.002 (0.58)
Johnson & Johnson	0.004 (0.78)	0 (0.02)	0.001 (0.64)
GlaxoSmithKline plc Adr	0.014 (2.28)*	0.008 (1.32)	-0.001 (0.22)
Sanofi-Aventis Ads	0 (0.01)	0.004 (0.49)	0 (0.05)
Amgen Inc	0.006 (0.84)	0.011 (1.43)	0.003 (1.04)
AstraZeneca Ads	0.01 (1.34)	0.011 (1.4)	-0.002 (0.55)
Abbott Laboratories	0.005 (0.81)	0.008 (1.24)	-0.001 (0.32)
Wyeth	0.007 (0.94)	-0.002 (0.32)	0 (0.15)
Lilly (eli)	0.008 (1.13)	0.007 (1.01)	-0.001 (0.49)
Bristol-Myers Squibb	0.002 (0.4)	-0.001 (0.1)	0 (0.03)
Schering-Plough	-0.006 (0.76)	0.006 (0.7)	0 (0.14)
Teva Pharm Indus Adr	-0.028 (3.21)**	-0.025 (2.78)**	0.004 (1.06)
Forest Labs	-0.02 (1.8)	-0.03 (2.66)**	-0.005 (1.29)
King Pharmaceuticals	-0.011 (0.73)	-0.002 (0.13)	0.006 (1.02)

* significant at 5%; ** significant at 1%, (Absolute value of t statistics)
1 – Merck Event Two, three-day dummy with day
2 – Merck Event Two, three-day dummy without day
3 – Merck Event Two, month after event

Table B4-2
Event two's reaction to the market on November 1, 2004 (*The Wall Street Journal* Report):

Company	Thremontwo (4) VWI	Monthbeftwo (5) VWI	Thremonbetwo (6) VWI
Merck & Co	0.001 (0.3)	-0.015 (3.58)**	-0.005 (2.02)*
Pfizer, Inc	-0.003 (1.63)	-0.002 (0.59)	-0.001 (0.66)
Johnson & Johnson	0.001 (1.21)	0 (0.22)	0 (0.26)
GlaxoSmithKline plc Adr	0 (0.03)	-0.002 (0.98)	0 (0.13)
Sanofi-Aventis Ads	-0.001 (0.48)	-0.001 (0.3)	0.001 (0.58)
Amgen Inc	0.001 (0.53)	-0.002 (0.64)	-0.001 (0.46)
AstraZeneca Ads	-0.001 (0.63)	0 (0.1)	-0.002 (0.88)
Abbott Laboratories	0.001 (0.4)	0 (0.04)	0.001 (0.81)
Wyeth	-0.001 (0.37)	0.002 (0.7)	0.002 (1.02)
Lilly (eli)	0 (0.09)	-0.005 (1.97)*	-0.002 (1.27)
Bristol-Myers Squibb	0 (0.31)	-0.001 (0.46)	0.001 (0.71)
Schering-Plough	0 (0.13)	-0.002 (0.64)	-0.002 (1.15)
Teva Pharm Indus Adr	0.002 (0.75)	-0.002 (0.58)	-0.003 (1.44)
Forest Labs	0 (0.18)	0 (0.02)	-0.001 (0.57)
King Pharmaceuticals	-0.001 (0.26)	-0.006 (1.04)	-0.002 (0.48)

* significant at 5%; ** significant at 1%, (Absolute value of t statistics)
4 – Merck Event Two, three months after event
5 – Merck Event Two, month before event
6 – Merck Event Two, three months before event

Table B5-1
Event three's reaction to the market on January 28, 2005 (US Court of Appeals Ruling):

Company	Mrkthree (1) VWI	Mrkthreewoday (2) VWI	Monafterthree (3) VWI
Merck & Co	-0.038 (3.43)**	0.002 (0.16)	0.007 (1.48)
Pfizer, Inc	-0.014 (1.78)	-0.008 (1.07)	0.004 (1.37)
Johnson & Johnson	0.004 (0.81)	0.004 (0.78)	0 (0.02)
GlaxoSmithKline plc Adr	-0.006 (0.98)	-0.002 (0.27)	0.003 (1.32)
Sanofi-Aventis Ads	-0.004 (0.6)	-0.007 (0.95)	0.002 (0.8)
Amgen Inc	0 (0.02)	0 (0.02)	-0.002 (0.55)
AstraZeneca Ads	0.006 (0.79)	0.01 (1.36)	0.003 (0.98)
Abbott Laboratories	-0.002 (0.33)	-0.001 (0.23)	0 (0.03)
Wyeth	-0.032 (4.63)**	-0.033 (4.79)**	-0.003 (1.23)
Lilly (eli)	-0.008 (1.11)	0.005 (0.73)	0.002 (0.7)
Bristol-Myers Squibb	-0.009 (1.58)	0.004 (0.65)	0.003 (1.34)
Schering-Plough	-0.004 (0.47)	-0.003 (0.32)	-0.001 (0.34)
Teva Pharm Indus Adr	0.01 (1.1)	0.007 (0.77)	0.002 (0.48)
Forest Labs	0.002 (0.16)	0.009 (0.88)	0.002 (0.58)
King Pharmaceuticals	-0.006 (0.4)	0.001 (0.06)	-0.006 (1)

* significant at 5%; ** significant at 1%, (Absolute value of t statistics)

1 – Merck Event Three, three-day dummy with day

2 – Merck Event Three, three-day dummy without day

3 – Merck Event Three, month after event

Table B5-2
Event three's reaction to the market on January 28, 2005 (US Court of Appeals Ruling):

Company	Thremonthree -4	Monthbefthree -5	Thremonbethree -6
	VWI	VWI	VWI
Merck & Co	0.005 (1.79)	0 (0.07)	0.001 (0.24)
Pfizer, Inc	0.004 (1.93)	-0.001 (0.45)	-0.002 (1.23)
Johnson & Johnson	0.001 (0.93)	0.001 (0.5)	0.001 (1.23)
GlaxoSmithKline plc Adr	0.002 (1.5)	-0.002 (0.79)	0 (0.28)
Sanofi-Aventis Ads	0.003 (1.73)	-0.003 (1.23)	-0.001 (0.45)
Amgen Inc	-0.001 (0.48)	0 (0.12)	0.001 (0.34)
AstraZeneca Ads	0.003 (1.93)	0.002 (0.55)	-0.002 (1.23)
Abbott Laboratories	0.002 (1.3)	0.001 (0.27)	0.001 (0.65)
Wyeth	0.001 (0.58)	0.001 (0.42)	0.001 (0.43)
Lilly (eli)	0.003 (1.57)	0 (0.03)	0 (0.12)
Bristol-Myers Squibb	0.003 (2.32)*	-0.001 (0.3)	0 (0.26)
Schering-Plough	0.002 (1.03)	-0.004 (1.18)	0 (0.22)
Teva Pharm Indus Adr	0.002 (0.77)	-0.003 (0.79)	0 (0.01)
Forest Labs	-0.001 (0.25)	-0.001 (0.34)	0 (0.19)
King Pharmaceuticals	-0.005 (1.36)	-0.007 (1.2)	-0.003 (0.78)

* significant at 5%; ** significant at 1%, (Absolute value of t statistics)

4 – Merck Event Three, three months after event
5 – Merck Event Three, month before event
6 – Merck Event Three, three months before event

Table B6-1
Event four's reaction to the market on February 18, 2005 (FDA Announces Support):

	Mrkfour (1)	Mrkfourwoday (2)	Monafterfour (3)
Company	VWI	VWI	VWI
Merck & Co	0.038 (3.34)**	-0.005 (0.44)	0.001 (0.12)
Pfizer, Inc	0.021 (2.63)**	-0.004 (0.45)	-0.001 (0.18)
Johnson & Johnson	0.002 (0.32)	0.002 (0.49)	0.001 (0.63)
GlaxoSmithKline plc Adr	0.013 (2.11)*	0.006 (0.95)	-0.001 (0.31)
Sanofi-Aventis Ads	0.016 (2.30)*	0.004 (0.57)	0.004 (1.32)
Amgen Inc	-0.002 (0.31)	0 (0.03)	-0.003 (0.96)
AstraZeneca Ads	0.017 (2.37)*	0.008 (1.06)	0.002 (0.63)
Abbott Laboratories	-0.004 (0.59)	0 (0.05)	-0.002 (0.92)
Wyeth	0.002 (0.31)	-0.001 (0.13)	-0.002 (0.61)
Lilly (eli)	0.001 (0.15)	0.004 (0.6)	-0.001 (0.55)
Bristol-Myers Squibb	0.016 (3.01)**	0.006 (1.15)	0.001 (0.28)
Schering-Plough	0.005 (0.63)	0.001 (0.09)	-0.004 (1.35)
Teva Pharm Indus Adr	0.01 (1.13)	0.003 (0.36)	0.005 (1.42)
Forest Labs	0.011 (1.1)	0.005 (0.52)	-0.005 (1.26)
King Pharmaceuticals	0.011 (0.77)	0.003 (0.23)	-0.007 (1.13)

* significant at 5%; ** significant at 1%, (Absolute value of t statistics)

1 – Merck Event Four, three-day dummy with day
2 – Merck Event Four, three-day dummy without day
3 – Merck Event Four, month after event

Table B6-2
Event four's reaction to the market on February 18, 2005 (FDA Announces Support):

Company	Thremonfour (4) VWI	Monthbeffour (5) VWI	Thremonbeffour (6) VWI
Merck & Co	0.001 (0.45)	-0.003 (0.61)	0.002 (0.73)
Pfizer, Inc	0.003 (1.48)	0 (0.16)	-0.001 (0.43)
Johnson & Johnson	0 (0.41)	0.002 (0.85)	0.001 (0.87)
GlaxoSmithKline plc Adr	0.001 (0.4)	0.001 (0.57)	0 (0.26)
Sanofi-Aventis Ads	0.002 (1.44)	-0.001 (0.51)	-0.001 (0.82)
Amgen Inc	0 (0.02)	-0.002 (0.75)	0 (0.03)
AstraZeneca Ads	0.002 (0.88)	0.005 (1.83)	-0.002 (1.12)
Abbott Laboratories	0.001 (0.96)	0 (0.02)	0.001 (0.83)
Wyeth	0.002 (0.93)	-0.003 (1.12)	-0.001 (0.31)
Lilly (eli)	0.002 (1.52)	-0.001 (0.54)	0 (0.18)
Bristol-Myers Squibb	0.002 (1.55)	-0.001 (0.53)	0 (0.15)
Schering-Plough	0.001 (0.43)	-0.003 (1.19)	0.001 (0.29)
Teva Pharm Indus Adr	0.003 (1.53)	-0.004 (1.08)	-0.001 (0.54)
Forest Labs	0 (0.14)	0 (0.09)	0.002 (0.75)
King Pharmaceuticals	-0.002 (0.47)	-0.005 (0.87)	-0.002 (0.69)

* significant at 5%; ** significant at 1%, (Absolute value of t statistics)

4 – Merck Event Four, three months after event
5 – Merck Event Four, month before event
6 – Merck Event Four, three months before event

Appendix C

FDA[31]

For a drug to be approved for sale in the US, it must go through a drug application process and be approved by the Food and Drug Administration (FDA). The drug's initial testing is dependent upon whether or not there is another chemical compound being distributed like it. If so, then the initial study is to collect data recorded by other uses of the drug. If the drug is a new compound, the sponsor must first show successful clinical trials on animals. This stage involves creating a drug profile and testing the drug, for toxicity, in two species of animals for short term tests ranging from two weeks to three months. To formally propose to the FDA that a new pharmaceutical drug should be approved, a sponsor must fill out the New Drug Application (NDA). In the NDA, a drug manufacturer will submit nonclinical and clinical (animal and human) test data, analyses of the tests, drug information, and a description of the manufacturing process. The FDA will then look at the NDA to decide if the drug is safe, has proper labeling, and if the manufacturing process is appropriate.

The clinical tests involve three phases of testing. Phase one is the initial testing of the drug in humans. This phase is usually done on healthy volunteer subjects and is closely monitored. In phase two the drug begins controlled setting tests. The second phase will also help determine the risks and short-term side effects of the drug. Phase two usually involves small groups for testing, several hundred patients. The third and final phase is comprised of clinical studies. This phase involves expanded controlled and uncontrolled

[31] Information from FDA website, www.fda.gov

trials. In the third phase, the risk-benefit relationship of the drug is supposed to be established. At any point during the three phases, if the study seems to be unsafe, a clinical hold can be put in place.

Appendix D

ADR

There are 3 stocks in this study that are traded on multiple exchanges, on what are called the American Depository Receipts, or ADR. The ADR was established to allow the stocks of foreign companies to be sold in the United States. An ADR is issued by a US Bank and represents a foreign stock. This ADR can represent one or more shares of the stock, or a fraction of the stock. Owning this ADR is owning the right to the foreign stock; however, although the ADR's tend to trade close to the price of the foreign stock, it represents, they are not always equal.

ADR's can come into two different categories Unsponsored and Sponsored:

Unsponsored – These ADR's are sold OTC, over-the-counter, and have no regulatory requirements. These shares can be issued to many different banks, with the banks only handling the shares that were given to them. Due to the lack of regulatory requirements, hidden fees can be very prevalent, so not many unsponsored ADR's are used anymore.

Sponsored shares are broken into three different levels, where the lowest level sponsored share is Level I.

Level I - This level requires a foreign firm to find a transfer agent, or one firm to issue sponsored shares. These shares can only be sold OTC and the company has a minimal set of reporting requirements set by the SEC (U. S. Securities and Exchange

Commission). Although they do have some minimal reporting requirements, they are not required to submit annual reports, although they can if they chose to do so.

Level II (listed) - To establish a level 2 program, a foreign company must register with the SEC, and this also allows the SEC to oversee the company's activities along with requiring the company to file yearly reports (20-F, similar to a US companies filing of a 10-K). The largest advantage of being listed as a level 2 is that these companies can now be listed on US stock exchanges.

Level III (offering) - Requires companies to adhere to the same standards as US companies. Level 3 also allows foreign companies not only to deposit shares into depositories, but also allows these companies the opportunity to issue shares to raise capital.

Appendix E

Fosamax

Fosamax (alendronate) is a once–a-week drug used to treat osteoporosis in women after menopause and to reduce the chances of having a hip or spinal fracture. Treatment has been shown to increase the bone mass in both women and men with osteoporosis with as little as three months treatment. Fosamax tablets can be taken as both a treatment and as prevention. Fosamax alters the cycle of bone formation and breakdown in the body, which is called a bisphosphonates.

Appendix F

USPTO

The Department of Commerce's United States Patent and Trade Office (USPTO) was established in 1790 to provide patent and trademark protection to inventors and companies. The first patent was issued on July 31, 1790 to Samuel Hopkins. The head of the USPTO is the Under Secretary of Commerce for Intellectual Property. The USPTO had around 8,000 employees and examined 332,000 patents in 2006.

The USPTO grants US Patents for intellectual property to inventor(s). According to the USPTO these patents are "the right to exclude others from making, using, offering for sale, or selling" the invention in the United States or "importing" the invention into the United States. To get a US patent, an application must be filed in the US Patent and Trademark Office.[32] Most patents filed today with the USPTO are done so electronically. These applications are evidence that your idea is unique, and also a manor for the USPTO to check that a patent is not something that has already been done by another. When a patent is filed filling, search, and examination fees must be paid, also with these initial patent filing fee a maintenance fee must be paid each year in order to maintain the patent rights. Generally the patentee has 20 years of patent protection from the date in which the patent was filed.

The USPTO also runs the US Court of Appeals, a court used to hear patent infringement cases. Teva Pharmaceuticals appealed Merck's lower court victory from the United

[32] From the US Patent and Trade Office's website, "How to get a patent."

States Court for the District of Delaware to the USPTO. On January 28, 2005 the court ruled that Merck & Co. infringed on Teva Pharmaceuticals patent. Teva Pharmaceuticals claimed that Merck was infringing on their patent, and appealed two parts of the lower court decision. The term 'about' was used, and in a lower court ruling was said to be clearly defined. Judge Reader said that about was a general term, not something used in a specific manor, and thus was invalid. The Judge said that the lower courts were wrong in their ruling of this case, and thus it was overturned. This means that Merck did infringe upon the Teva Pharmaceuticals patent, and thus will lose time on their patent. The patent life of Fosamax was shortened from expiring in 2018, to expire in 2008.

Appendix G

Detailed Time-Line

Jan. 2, 1970	Merck's IPO, opening the first day at $112.75.
Nov. 23, 1998	Merck submits NDA (New Drug Application) for approval of Vioxx from the FDA.
Jan. 1999	Merck begins VIGOR (Vioxx Gastrointestinal Outcomes Research), a trial to test the impact of Vioxx. Merck claims "similar" cardiovascular risk among patients taking Vioxx and those on placebo or other pain relievers.
May 20, 1999	FDA approves Vioxx. (Closing price of $72.25, which is a one-day increase of 2.48%)
Feb. 2000	APPROVe (Adenomatous Polyp Prevention Vioxx) begins enrollment for a trial to test the effects of Vioxx on the recurrence of neoplastic polyps of the large bowel in patients.

Nov. 23, 2000	VIGOR, which was designed to find the side effects of Vioxx, such as stomach ulcers and bleeding, is published in *The New England Journal of Medicine*.[33]
May 22, 2001	Merck issues a press release titled "Merck Confirms Favorable Cardiovascular Safety Profile of Vioxx."
Sept. 17, 2001	The FDA sends Merck a "Warning Letter" demanding that Merck discontinue the promotion of Vioxx to doctors for unofficial uses.[34]
Apr. 11, 2002	Merck revises the Vioxx label to include precautions about cardiovascular risk cited in the VIGOR trial.[35]

[33] According to Merck, after the journal's deadline for submission, this study revealed a statistically significant increase in the number of cardiovascular events, heart attacks, and strokes in patients taking Rofecoxib (Vioxx) as compared to those taking Naproxen (the original transcript was submitted in May of 2000). The published article said that there was no increase in cardiovascular events, heart attacks or strokes. The additional information led to an Arthritis Advisory Committee discussion that added safety information to the label of Vioxx in April 2002.

[34] Merck was marketing Vioxx for uses in arthritis treatments that had not been proven to the FDA's satisfaction.

[35] The VIGOR study found that of the 4047 patients taking rofecoxib 111 had cardiovascular events (2.7%), while of the 4029 patients taking naproxen 50 had cardiovascular events (1.2%). This shows Vioxx has 2.2 times higher chance of having a cardiovascular event then does naproxen. This is a RR (relative risk) of 2.22 and a RD (risk difference) of 44%, found in Mukherjee, Nissen, Topol (2001).

Sept. 30, 2004 – 'Event One'	Merck voluntarily removes Vioxx from the shelves after the APPROVe study finds that those patients taking 25 mg of Vioxx for more then eighteen months have an increased risk of suffering a heart attack, stroke, or other cardiovascular event.
Nov. 1, 2004 – 'Event Two'	*The Wall Street Journal* reports that Merck executives were worried in the mid-to-late 1990's that Vioxx would show greater heart risk than cheaper painkillers which are harsh on the stomach but are believed to reduce the risk of heart attacks.
Dec. 23, 2004	The FDA issues a public health advisory urging doctors to carefully weigh the risks in prescribing medications for arthritis and pain, suggesting limited use of Cox-2 inhibitors. (This includes Vioxx)
Jan. 28, 2005 – 'Event Three'	The US Court of Appeals in Washington rules that the company will lose its patent on the osteoporosis drug Fosamax by 2008 (initially set to expire in 2018). This causes Merck's stock to fall ten percent, as this is Merck's second biggest seller, with sales of $3.2 billion in 2004.

Feb 18, 2005 – 'Event Four'	The FDA releases an announcement saying they believe that the Cox-2 inhibitors' benefits outweigh the increased chance of a cardiovascular event caused by the drugs.
April 7, 2005	Pfizer removes Bextra from the market and changes the label of Celebrex after being told to do so from FDA.
Aug. 19, 2005	Merck loses Ernst v Merck case. Merck is found guilty by a jury in the death of Robert Ernst, a Texas man who took the pain killer Vioxx. Robert Ernst's widow is awarded $750,000 in damages, and an additional $24 million for mental anguish and $229 million in punitive damages.[36] Merck argues that Ernst died of clogged arteries, not a Vioxx-induced heart attack. Merck plans to appeal. They also begin to battle 4,200 other state and federal pending lawsuits. (first case)
Nov. 3, 2005	Merck wins Humeston v Merck case. Frederick Humeston from Boise, Idaho, claimed that his heart attack suffered on September 18, 2001 was a result of intermittent use of Vioxx over a two-month period. (second case) On March 13, 2007 the jurors awarded $20

[36] Texas law limits the punitive damages to two million dollars if this case is upheld through the appeals process.

	million in compensatory damages, then later said Merck should pay $27.5 million in punitive damages.
Dec. 12, 2005	Mistrial declared in Irvan v Merck in a Houston Texas trial brought by Richard Irvan's widow. Just prior to his death in 2001, Irvin had been taking Vioxx for about a month for back pain. As of Dec. 12, 2005, Merck is facing 7,000 cases over Vioxx.[37] (third case, first federal case)
Feb. 18, 2006	Merck wins Irvan v Merck case. The New Orleans jury finds Merck wasn't responsible for the previous Irvan case that was declared a mistrial in Houston December 12, 2005. (The original case was held in Houston, rather then New Orleans, due to hurricane damage.) Evelyn Irvin Plunkett, widow of Richard 'Dicky' Irvin, alleges his May 2001 heart attack came after taking Vioxx for about a month. (third case)

[37] One week before the mistrial, *The New England Journal of Medicine* claimed that Merck-sponsored scientists manipulated the cardiovascular data from a Vioxx study published in November 2000. Editors of the journal accused the study's authors of knowingly omitting the data from the publication's final draft. Merck claims that the heart attacks in questions happened after the journal's deadline for submission and were promptly reported to the FDA. Federal Judge Eldon Fallon declared a mistrial of the case, stating that the jury had not been able to reach a verdict in a timely manner.

Apr. 5, 2006	Merck loses McDarby v Merck case, wins Cona v Merck case. John McDarby was awarded damages of $4.5 million, while Merck was absolved Merck in the case of Thomas Cona. (fourth and fifth cases)
Apr 21, 2006	Merck loses Garza v Merck case. A jury in Rio Grande City, Texas orders Merck to pay $32 million for the death of 71-year-old Leonel Garza. On March 8th, 2007 the verdict stands with Merck to pay Garza $7.75 million. (sixth case)
Jul. 13, 2006	Merck wins Doherty v Merck case. The New Jersey jury ruled that Vioxx was not a substantial factor in Elaine Doherty's death. (seventh case)
Aug. 2, 2006	Merck wins Grossberg v Merck case. Stewart Grossberg took Vioxx before his heart attack at age 66, on September 18, 2001. "We firmly believed that Vioxx was not the cause of this heart attack because the data do not support that infrequent, sporadic use of Vioxx contributes to heart attacks," said Thomas Yoo, a member of the defense team, in a statement. "At the end of the day, the fact remains that the plaintiff was at high risk for

	a heart attack regardless of whether he was taking Vioxx." (eighth case)
Aug 17, 2006	Merck loses Barnett v Merck case,[38] and Merck's November win is thrown out. Gerald Barnett was taking Vioxx for 33 moths prior to suffering his hear attack in September 2002 and two years afterwards. He was awarded $51 million in damages, but the judge ruled that the jury's verdict will stand, but the $51 million in compensatory damages were unreasonable. The jury also found that Merck "knowingly misrepresented or failed to disclose" information about Vioxx to the doctors of the 62-year-old, media reports. The same day a New Jersey judge threw out Merck's win from the November Humeston v Merck case. (ninth case)
Sept 26, 2006	Merck wins Smith v Merck case. A New Orleans jury found that Merck did not cause a 2003 hear attack of Robert Smith, 56. Merck's lead trial lawyer, Philip Beck, said "Unfortunately, Mr. Smith would have suffered a heart attack whether he was taking Vioxx or not." (tenth case)

[38] Since this case the judge ruled that the jury's verdict that Merck is liable in the case will stand, but the $51 million in compensatory damages were unreasonable. (8/31/06)

Dec 13, 2006	Merck wins Dedrick v Merck case. “The [New Orleans] jury determined that Merck acted appropriately in the development and marketing of Vioxx, and that Vioxx did not substantially contribute to Mr. Dedrick's heart attack," said Merck's attorney, Phil Beck, of the Chicago law firm Bartlit Beck Herman Palenchar & Scott. (eleventh case)
Dec 16, 2006	Merck wins Albright v Merck case. An Alabama state court jury said that the pain reliever didn't cause Gary Albright’s March 2001 heart attack. Merck pointed out during the trial that he continued to take Vioxx until September 2004 when the company pulled it from the market. Merck said Albright, now 58, had high blood pressure, diabetes and high cholesterol and was obese, all risk factors for heart disease. (twelfth case)
Jan 18, 2007	A mistrials declared on Appell v Merck and Arrigale v Merck. Los Angeles judge declared two mistrials when the juries couldn’t come to a decision on the Scottsdale, AZ man, Lawrence Appell. Appell suffered a heart attack in Dec of 2000 at the age of 51, which he blames on Vioxx. He continued to take Vioxx until it was withdrawn in September 2004. Rudolph Arrigale of Westminster, CA said he used the pain killer for four and

	a half months before his heart attack in March, 2002 at the age of 72.
Mar 2, 2007	Merck wins Hermans v. Merck, but loses Humeston v. Merck. The Atlantic City jury split their ruling for the Merck cases. The jury split the cases because they believed that Merck gave proper warning before Hermans's Death (September 15, 2002, at age 44), but not before Humeston's death, at age 61, one year earlier.

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