Strategic Advertising: Evidence in the Pharmaceutical Industry*

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Abstract

In this paper, we investigate the change in advertising patterns of competing pharmaceutical firms in the short period after a new entrant, Crestor, is petitioned to be removed from the Statin drug market. Using physician-level data, we find that Crestor's main competitor, Lipitor, increases its advertising intensity the most among physicians with whom Crestor already has a median share of total prescriptions. Moreover, such change in advertising patterns does not occur with Crestor's other smaller opponents. These findings support the view that Lipitor strategically advertises to induce the exit of Crestor, while raise doubt on the hypothesis that Lipitor's advertising is a normal competitive response to the bad news.

Keywords: Strategic advertising, Predation, Exit

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1 Introduction

The theoretical literature identifies several strategic usages of advertising to affect firms' entry/exit decisions.[1] However, empirical study on strategic advertising is just getting underway (Bagwell (2007)). In this work, we analyze the change in advertising patterns of incumbent firms after a new entrant was petitioned to be removed from the market. We find evidence supportive to the argument that, the dominant incumbent firm strategically advertised with an intention to induce the future exit of the new entrant.

Our investigation is based on a high-profile case in the Statin drug market. Crestor, a brand that belongs to a therapeutic class of Statin drugs, first entered the market in August 2003. Shortly after its entry, several cases of severe side effects occurred from the use of this brand. Alarmed by the potential risk, on March 4, 2004, Public Citizen, a very influential consumer advocacy group, submitted a petition to the Food and Drug Administration (FDA) to formally remove the brand from the market. This bad news was immediately picked up by major news networks, such as CBS. Interestingly, a different Statin brand, Baycol, was also petitioned by Public Citizen in 2001. As a consequence of a similar bad news, Baycol withdrew from the market.

In the period immediately following the bad news of Crestor, all Statin drugs increased their physician detailing level.[2] Among Crestor's opponents, Lipitor is the dominant

[1] One argument is based on the "goodwill" effect of advertising. Schmalensee (1983), Fudenberg and Tirole (1984), Doraszelski and Markovich (2007) find that, when advertising generates "captive" consumers, there can be either under-investing or over-investing in advertising by incumbent to deter entry. A second rationale is based on the "noise" effect of advertising. Hilke and Nelson (1984) argue that an incumbent may overinvest in advertising to jam consumer's message space, therefore inducing rival's exit. The third line of explanation is based on the "signaling" effect of advertising. Bagwell and Ramey (1988, 1990), Linnermer (1998) show that an incumbent may distort its advertising to signal its private information regarding cost/demand/quality, aimed at deterring entry. See Bagwell (2007) for a comprehensive survey.

[2] Detailing is the major form of advertising in the pharmaceutical industry, referring to visit of pharma-

brand accounting for more than 40 percent of the total sale of Statin drugs, and is Crestor's major rival. After the shock, Lipitor increased its detailing by 12 percent.

The central question of our study is: how do incumbent firms respond in advertising to the petition on Crestor's withdrawal? In particular, is there strategic consideration in their advertising behavior to accelerate the withdrawal of Crestor?[3]

To address these questions, we use a physician-level panel data set covering the periods preceding and following the bad news. For each physician, we observe the prescription level and the number of sales representatives visits for each Statin drug. We focus on the dominant brand, Lipitor, to investigate the change of incumbents' advertising patterns.

The method we use in the baseline empirical work includes a Difference in Difference study and a parametric regression model. Both methods give us consistent findings. After the bad news, Lipitor demonstrates a significantly larger increase in its advertising among physicians with whom Crestor has a median market share, relative to the increase in its advertising among physicians where Crestor's market share is either low or high. These results are robust under various model specifications. Interestingly, such pattern in Lipitor's advertising is more prominent within physicians who have relatively small number of total Statin drug prescriptions.

One justification for the above empirical findings is offered by Chen and Tan (2009), in which they argue that a predatory response of Lipitor to the bad news can generate the observed change in its advertising patterns.[4] The intuition is that, while the shock negatively affects physicians' willingness to prescribe Crestor, Lipitor's intention to predate varies across physicians. For physicians who have a high prior demand of Crestor,

ceutical sales representatives at physicians' offices.

[3]The bad news does not necessarily generate the pressure for Crestor to leave the Statin market immediately. Thus, we consider the withdrawal decision at the physician level, where Crestor "withdraws" from a physician market if it ceases to send sales representatives to the physician's office.

[4]They consider each physician as a market and the withdrawal decision is made at the physician level.

the post-news demand is likely to be large enough for Crestor to stay in profit, making predation impossible. On the other hand, for physicians who have a low prior demand of Crestor, the post-news demand is likely to be so low that Crestor will naturally drop out, making costly predation unnecessary. Therefore, the strongest incentive for Lipitor to prey arises with physicians whose prior demand of Crestor lies in the median range. Chen and Tan (2009) formalize the analysis in a signaling game, which predicts an upward distortion in Lipitor's advertising, due to its predatory intention, among physicians where Crestor enjoys a median prior demand.

One could also argue that, the change in Lipitor's advertising patterns is simply driven by its normal competitive response to the bad news. Namely, Lipitor intends to grab a larger market share and maximize its profit, without caring about Crestor's possible exit in the future. We could not formally rule out this explanation. However, further exploration of data casts doubt on this hypothesis. Firstly, Lipitor does not exhibit a similar upward-distortion in its advertising patterns with physicians where other Statin brands have a median market share. Since the news affects only Crestor, we expect that Lipitor should use normal competitive advertising strategy towards other Statin brands. Secondly, Zocor and Provachol, two brands with much weaker incentive to prey on Crestor,[5] change their advertising patterns in a significantly different way compared with Lipitor. Neither brand increases advertising the most among physicians where Crestor has median market share. Such findings persist even if we only look at physicians where Zocor/Pravachol has a relatively large market share.

The rest of the paper is organized as follows: Section 2 reviews the literature. Section 3 introduces the background regarding the Statin drug market and the bad news event. Section 4 discusses the potential strategic response of incumbent firms to the petition

[5]Their market share is much smaller than that of Lipitor. Besides, their patents are expiring soon at the time of the bad news. Zocor and Provachol's patents expire in 2006, while that of Lipitor expires in 2010.

of Crestor's withdrawal. Section 5 describes data. After that, Section 6 provides the empirical strategy together with a Difference-in-Difference study. Section 7 gives the empirical model and results, followed by a discussion on the alternative explanation in Section 8. Then Section 9 concludes.

2 Literature Review

Our work is closely related to empirical studies of predatory practice. Relatively few empirical evidence of predation exists, despite the extensive theoretical literature on this topic.[6] Morton (1997) examines the response of the British shipping cartel to the entry of new shipping lines. Incumbent cartels are found to be more likely to start a price war after the entry of "weaker" firms. This provides support for the "long purse" theory of predation. Genesove and Mullin (2006) study entry into the American sugar refining industry. They find that the price wars following entry were predatory by first comparing the price to the marginal cost and then comparing the predicted competitive price-cost margin to the observed margins.

Another related literature is the empirical study of the strategic use of pricing/advertising to deter entry. In a manner closely related to our work, Ellison and Ellison (2007) examine the behavior of pharmaceutical incumbents in the period prior to the expiration of their patents. They identify evidence of entry deterrence by investigating whether the incum-

[6]Beginning in the 1950s, "Chicago School" economic analysis, assuming complete information, rightfully pointed out the irrationality of monopolizing a market through predation (McGee (1958, 1980)). On the other hand, modern strategic analysis have resurrected the logic of predatory practice. The key assumption is the absence of perfect information; under such conditions, predation becomes a rational strategy, even for a predator without efficiency or financial advantages over its prey. Many intrinsic incentives have been identified in favor of predation. To cite several of these works, see Milgrom and Roberts (1982), Kreps and Wilson (1982), Fudenberg and Tirole (1986), Roberts (1986), Saloner (1987), etc..

bent's behavior is non-monotonic relative to the size of the market. Large markets are so attractive that deterring entry is never optimal; while small markets inherently defy entry, making entry-deterring investment unnecessary. Morton (2000) tests whether incumbents facing generic entry increase advertising in order to deter entry, and finds no evidence supportive of brand advertising as constituting an entry barrier. Goolsbee and Syverson (2004) use data from major airlines to study how incumbent carriers respond to the threat of the entry of Southwest Airlines. They find evidence consistent with theories claiming that incumbents try to construct longer-term loyalty before entry occurs.

Our work is also related to the large empirical literature on entry and exit in the market. The majority of empirical studies on entry and exit belong to the class of "equilibrium entry/exit models" pioneered by the influential studies of Bresnahan and Reiss (1988) and Berry (1992). A common feature of those studies is their assumption that the observed market structure is at equilibrium. As such, even though the studies try to understand entry and exit, no actual entry or exit is observed in the data. In addition, equilibrium entry/exit models often ignore how firm strategies – such as price and advertising – affect entry and exit.

There is also a literature empirically testing strategic advertising to signal product quality. Using U.S. automobile industry data, Thomas, Shane and Weigelt(1998) find an upward distortion in advertising with those products whose prices are also upward distorted. This finding is consistent with signaling game theory, which says that firms with higher quality would use advertising together with price to signal the quality of unobserved attributes. Horstmann and MacDonald (2003) test if advertising is a signal of product quality in the compact disc player market. They find that the advertising and pricing patterns can be explained by signaling game involving persistent consumer uncertainty and learning.

3 Background

3.1 The Statin Drug Market

Statins are drugs that help lower cholesterol levels. With at least 12 million Americans taking cholesterol-lowering drugs — most of them Statins — and experts recommending that another 23 million take them, Statin drugs are certainly very important to the pharmaceutical industry. In many cases, Statin drugs are the number one seller of their company. With sales for 2004 reaching US $10.8 billion and 5.2 billion respectively, the top two brands in the market, Lipitor and Zocor, are not only the largest seller for their maker, Pfizer and Merck & Co, but also the largest two selling drugs in the world.

Table 1 tabulates for major brands, chemical content, production method, generic availability, makers, market share in 2004 and patent expiration date for the top brands. Based on chemical content, there are six competing products in the market:[7] Crestor (rosuvastatin), Lescol (fluvastatin), Lipitor (atorvastatin), Pravachol (pravastatin), Zocor (simvastatin) and lovastatin (Mevacor). Only lovastatin has a number of generic products. During our study period, although generic brands are available, the market is dominated by the branded drug. The four main brands in the market are Lipitor, Zocor, Pravachol and Crestor. Their makers are Pfizer, Merck, Bristol-Myers Squibb and Astra Zeneca respectively. Among them, Lipitor and Crestor are considered closer substitutes as they use the same production method (Synthetic). Moreover, Zocor and Pravachol's patents expire in 2006, while Lipitor's patent expires in 2010.

[Insert Table 1 Here]

[7] If two drugs have the same chemical content, they should be considered the same product from a chemical point of view. Of course consumers may have different preference towards drugs of the same content. This difference may be caused by various reasons, such as brand image effect, advertising and different ways of packaging the product, etc.

Pharmaceutical companies mainly compete through advertising and marketing promotions. Excepting direct to consumer advertising, the most commonly used marketing methods are pharmaceutical sales representatives' visits to physicians' offices, referred to as "detailing". Detailing is widely viewed as a means of building a relationship with a particular physician. During the office visit, a sales representative will show the physician various findings that support the use of the relevant drug. The sales representative will also leave free samples for the physician to distribute to patients. According to industry convention, each sales representative is only allowed to visit the same physician once a month. However, if a firm wants to have more than one detailing per month at a given physician's office, it can employ several sales representatives, having each visit the physician at a different time during the month.

3.2 News Event

The drug that suffered the bad news is Crestor. It first obtained FDA approval on August 12th, 2003, and entered the market shortly afterward. After entering the market, several severe cases of side effects occurred. Alarmed by the findings, a very influential consumer advocacy group, known as Public Citizen, submitted on March 4th, 2004, a formal petition to FDA to have the drug removed from the market. According to its petition, "three patients in the United States who were taking approved doses of rosuvastatin developed kidney failure or muscle damage. One of those patients, a 39-year-old woman, died of kidney failure and rhabdomyolysis, or muscle damage. Data obtained from the United States, the United Kingdom and Canada show seven cases of rhabdomyolysis and nine case of kidney damage or failure occurred after FDA approval." Major news network, such as CBS, immediately broadcasted the news about the petition from Public Citizen. Crestor's maker AstraZeneca wouldn't comment on the deaths or any other serious side effects, except to say that "the safety profile is totally comparable" to what pre-marketing

studies had predicted.

Interestingly, this is not the first time that Public Citizen issued a petition for the removal of a Statin drug. Baycol, another Statin drug, withdrew from the market in the fall of 2001 following a petition by Public Citizen to FDA. The side effects of Baycol were very similar to those of Crestor, in that they were both likely to cause kidney damage. Not surprisingly, Public Citizen emphasized the similarity of the two drugs and noted the withdrawal of Baycol in their petition to FDA.

In addition, the news breakout is clearly not anticipated by a regular physician or a patient. Although it is possible that before the news event, physicians may have heard about the incidence of severe side effects from other sources, such as sales representative visits, medical journals and professional conferences, etc., the formal petition of Public Citizen to FDA and subsequent mass media coverage still brings additional information to physicians. Moreover, it is very likely that this is the first time that a patient will receive any news about Crestor's side effect. Thus patient's reaction may influence physicians' prescription decisions as many studies have argued that patient also plays an important role in medical treatment decision. Therefore, the news event provides us a unique opportunity, i.e., a "natural experiment", to study the changes in advertising strategies of pharmaceutical firms after the news event.

We argue that, after the petition of Crestor's withdrawal, its competitors may attempt predatory advertising to induce Crestor's exit. While the news event seriously lowered Crestor's demand and raises questions among physicians and patients about the possibility of Crestor's withdrawal, it is not severe enough to force Crestor to exit immediately. While Crestor remains active in detailing, its competitors may employ predatory strategy to convince Crestor that staying in certain markets is no longer profitable.

4 Potential Response of Incumbent Firms to the Petition of Withdrawal of Crestor

When the news of Public Citizen's petition was released, Crestor needed to decide either to stay (continue with detailing) or to withdraw from the market, depending on the severity of the shock. Since Crestor's competitors had witnessed a similar withdrawal petition by Public Citizen on another drug, Baycol, and its subsequent withdrawal three years ago,[8] is it possible that those incumbent firms could use "predatory" strategies to induce Crestor to leave the market?

The basic idea of predation is that, a firm may sacrifice part of the profits that could be earned under competitive circumstances in order to induce the exit of an opponent, therefore gaining additional profits in the future. The extensive theoretical works of modern game theory provide various scenarios where predation becomes rational strategy. A common feature of these theoretical models is the existence of asymmetric information.

Chen and Tan (2009) formally model the post-news competition based on a signaling game, which shows that predatory strategy arises in equilibrium. They argue that predation can be rational in this case because of the asymmetric information regarding the severity of the bad news. Since Crestor was a new entrant at the time of the shock, and it was Crestor's first time experiencing such bad news, there was likely uncertainty in Crestor's belief regarding how badly the news was going to impact physicians' perception of Crestor. While Crestor's competitors, having witnessed a similar bad news event three years ago, were likely to possess superior information regarding the severity of the bad news. In their model, the effect of the bad news can be either mild or severe, which is unobserved by Crestor but is observed by its competitors. In the period immediately following the shock, Crestor remains active in the market to infer information about its

[8] For more details regarding the Statin drug market and the news event, see Section 3.

future profitability. At the same time, its competitors might try to signal Crestor their information regarding the effect of the shock through their advertising. In particular, they would have incentive to employ predatory strategy to convince Crestor an intrinsically bad market situation, therefore to have Crestor withdraw from that market.

Chen and Tan (2009) find that the model admits two types of equilibrium, separating equilibrium and pooling equilibrium. They compares the resulting equilibrium advertising level with the normal competitive advertising level where the incumbent firms maximize their post-shock profits without caring about Crestor's future exit decision. In both types of equilibrium, predatory intention can lead to higher than normal competitive level of advertising by the incumbent firms. In the unique intuitive separating equilibrium, when the shock is severe, incumbent firms advertise at a strictly larger amount compared to the normal competitive level in order to reveal Crestor an intrinsically unprofitable market circumstance. While, in the least-cost intuitive pooling equilibrium, incumbent firms raise advertising above normal competitive level when the shock is mild to disenable Crestor's reference of the real market situation and lead to its voluntary exit.

Another feature of Chen and Tan (2009) is that the predatory intent only exists in those markets where demand on Crestor prior to the news event is neither too low nor too high. In markets with very low prior demand of Crestor, predation is not necessary because Crestor is optimal to exit even if the shock is mild, while in markets with high prior demand of Crestor, predation is not possible as Crestor will stay regardless of the severity level of the shock.

To summarize, Chen and Tan (2009) predict that the incumbent firms advertise more than the normal competitive level among those markets where the prior demand for Crestor is in the median range. Thus if the observed difference in incumbent advertising level before and after the news is non-monotonic in prior demand for Crestor, it might suggest that incumbent firms adopt predatory strategies. The intuition of the results is

very similar to that of Ellison and Ellison (2007), where the strategic use of advertising to deter entry occurs only in markets with intermediate probability of entry.

An alternative explanation of the non-monotonic change in advertising before and after the news is that, Lipitor takes a normal competitive response to the bad news, i.e., it is maximizing post-news profit without caring about Crestor's future exit decision. We will address this alternative explanation in section 8.[9]

5 Data

The data used for the empirical analysis is from a category of prescription drug used to treat high levels of blood cholesterol; such a drug is commonly referred to as a Statin drug. The data are at the level of physician, and are based on a panel of representative physicians from the United States. These data are obtained from a pharmaceutical consulting firm, which also provided a similar dataset to a marketing study by Narayanan and Manchanda (2005). For each physician, we observe a sample of prescriptions between January 1st 2004 and December 31st 2004. In addition, we also have a record of all the detailing visits made by pharmaceutical sales representatives during the same period. The dataset is unique in that we observe both the prescription level and the detailing frequencies of all firms at the physician-level. This enables us to look at how Crestor's competitors change their detailing strategies with respect to different physicians.

According to the convention of the industry, each sales representative can visit a physician's office only once within one month, thus it is likely that pharmaceutical firms make their advertising decision on a monthly basis. Therefore we create a monthly physician panel data. For each physician we calculate the total number of sales visits and total pre-

[9] Chen and Tan (2009) show that, under certain conditions of the demand function, if Lipitor takes normal competitive response, the change in Lipitor's advertising before and after the news must be monotonic in Crestor's prior demand. However, we are not able to empirically test whether such conditions hold.

scriptions for all drugs in each month. Since the news event happens on March 4th 2004, which is the 9th week in our dataset, we decide to exclude week 9 from our study to give firms enough time to adjust to the news event. Our study focuses on changes in detailing patterns right after the news. Thus we use a short time window and exclude observations after week 13, which is five weeks after the news event. We make some adjustment in our definition of a month. We divide the time before and after the news into three periods of equal length: week 1-4(January), week 5-8 (February) and week 10-13 (March). An advantage of constructing the time period this way is that we make sure our comparisons are based on the same length of the period.

An important part of our study requires us to create measures of monthly market share. During our sample period, Crestor's share of total prescription is around 10 percent. However, some physicians in our data set have a very small number of prescriptions during each month. We are concerned that including those physicians will make our measure of market share very noisy and increase the risk of misclassifying a physician's market share level. For example, if we observe only one prescription for a physician in a given month and that prescription happens to be Crestor, we will infer that Crestor has a 100 percent market share for that physician. Clearly, we are not as confident to classify the physician as having high Crestor market share as another physician who prescribes 10 Crestor among 10 prescriptions. In order to have a reasonable large prescription levels to calculate market share, we restrict our sample to physicians with 10 or more prescriptions in both week 1-4 and week 5-8. This restricts our dataset to 308 physicians for whom we observe monthly detailing as well as prescription decision in all three months.

Table 2 summarizes the information of prescription levels and detailing intensities for our sample physicians. The average number of total prescriptions in a month is 20.54 with a maximum of 75. Average share of Crestor's prescription is 9 percent. Lipitor has the largest market share at 43 percent, followed by Zocor at 24 percent and Pravachol at

13 percent. The average number of detailing by Lipitor, Zocor, Pravachol and Crestor are 0.83, 0.89, 0.58 and 1.29 respectively. Crestor has the highest level of detailing intensity in part due to that it just entered the market about four months ago. In addition, because of the negative news event, Crestor may increase its advertising level to counteract the news effect. It is clear that all brands exhibit considerable variations in detailing intensity across physicians. For example, the maximum number of monthly visits by Lipitor to a physician is 6, while to some physicians there is no visit at all. Table 2 also shows the distribution of market shares for each drug. Among physicians with at least one prescription of Crestor, the 25th quantile, median and 75th quantile of Crestor's market share are 0.07, 0.11 and 0.20 respectively. It is worth mentioning that the distribution of Pravachol's market share is the closest to that of Crestor. We do not observe physicians' personal characteristics, such as their education or type of practice. Nevertheless, we report in Table 2 measures of patients' mix at physicians' offices, including the share of new patients, the share of patients aged 65 or above, the share of Asian patients, the share of female patients and the share of patients with severe symptoms. On average, new patients, patients aged 65 or above, Asian patients, female patients and patients in severe symptoms accounts for 10 percent, 47 percent , 2 percent , 47 percent and 6 percent, respectively.

[Insert Table 2 Here]

6 Empirical Strategy

The objective of the study is to examine the changes in the incumbent firms' advertising patterns across different markets after the bad news to Crestor. We are particularly interested to see whether the change in the incumbent advertising is non-monotonic in the prior demand of Crestor, and whether incumbent firms increase advertising the most among markets where the prior demand for Crestor is in the median range.

We treat each physician as a market,[10] and use Crestor's share in a physician's total prescriptions as the measurement of the prior demand for Crestor. We focus on the response of Lipitor, as it is the dominant brand in the Statin drug market counting for more than 40 percent of the total sale, and also the closest substitute for Crestor. The second and third largest brand, Zocor and Provachol, count for 23 percent and 11 percent of the total sale, respectively (see Table 1). Moreover, patents of Zocor and Provachol are expiring soon at the time of the bad news. Therefore, the incentive to use predatory advertising, if it exists, should be the strongest with Lipitor. We will also examine the changes in Zocor and Pravachol's advertising patterns in section 8 when we discuss the alternative explanations.

We want to emphasize that we are examining the change in Lipitor's advertising strategy before and after the news event, rather than the actual outcome of such strategy. The main reason is that, even if Lipitor's post-news advertising is indeed predatory, it is very difficult to know how long it takes to have any effects. In addition, the information flow is constant in the Statin drug market. After the bad news event, there might be other additional information released to the public. For example, we observe that FDA changed the warning on the label of Crestor three months after Public Citizen's petition. These additional information certainly will have effects on Lipitor's strategy, which we are not able to control for in our model. As such, we focus on the short time window around the news event, so that the results are mostly driven by the bad news rather than additional information released afterwards.

We focus on the changes in detailing strategy rather than price and other competition

[10] As the bad news does not force Crestor to fully pull out the Statin drug market, the exit decision is more relevant at the physician level. We consider Crestor as having exited from a physician market if it foregoes relationship building with that physician by ceasing to send sales representatives. As long as Crestors competitors prefer its exiting (stopping detailing a physician), the intrinsic incentive of predation still holds under our definition.

practice, such as direct to consumer advertising. The reason is that, we look at the immediate response of firms after the news event,[11] whereas firms' change in price and direct to consumer advertising is likely to take longer time to occur. In addition, we explore how the changes in firms' strategies differ across different types of physicians. In our data, only detailing activity varies across physicians, while price and direct to consumer advertising are constant.

6.1 A Difference in Difference Study

The main idea of a Dif-in-Dif (Difference in Difference) Study is to compare the changes in the outcome variable of the comparison group with that of the control group.

In our baseline Dif-in-Dif estimation, the outcome variable is Lipitor's number of detailing. Ideally, we would like to look at the change in Lipitor's number of detailing during a short time window around the event date, March 4th, 2004. However, we also need a large data set to provide a test with appropriate power. As the news happens on March 4th (week 9), we compare the number of detailing in February (week 5-8) with that in March (week 10-13). As described in Section 5, by defining the time period this way, we guarantee the comparisons are done over the exact same number of periods.

In our baseline Dif-in-Dif estimation, the comparison group includes physicians whose prescription level of Crestor before the news falls in the median range. For the control group, we use two different specifications: physicians with low prescription level of Crestor and physicians with high prescription level of Crestor. By using these control groups, we control for the expected differences in detailing due to other factors that are not associated with the news event, such as the seasonal effect. It is worth mentioning that our test objectives are different from the standard Dif-in-Dif estimation. We are not trying

[11] We expect the effect of the bad news to be the strongest in the period immediately following the news event, together with the incentives for Crestor's competitors to use predatory strategies.

to estimate the causal effect of news event on detailing level. Instead, we are interested in testing if the detailing level of Lipitor increases more in the comparison group than in BOTH control groups.

We use the market share of Crestor in week 1-8 to categorize a physician. Unfortunately, there is no guideline for us to determine the range of market share where predatory intent exists. We decide to use the quantile of Crestor's market share distribution to determine the ranges. Based on week 1-8 prescription data, the 25th percentile of Crestor's market share is at 0.05, and the 75th percentile is at 0.18. We choose to categorize a physician as Low, Median, and High type if the market share of Crestor is between [0-0.05), [0.05-0.18], and (0.18, 1] respectively. We try to categorize more physicians in the median type and avoid the potential problems of misclassifying a median type physician into either low or high type. The downside of having a large size of median type is that we may include low or high type physicians as median type, which in turn may weaken our test results. Clearly, the misclassification of market share ranges is a potential problem. We check the robustness of our results using alternative definitions of market share ranges. Most of the results will hold if we use alternative but similar categorization of market share ranges.

The baseline Dif-in-Dif results are reported in Table 3. During the four weeks before the news event (week 5-8), the average number of Lipitor detailing to median type physicians is 0.76, while the number of detailing towards physicians of low and high types are 0.73 and 0.82 respectively. After the news event, the average number of Lipitor's detailing during week 10-13 increases to 0.92 among median type physicians. For the low type physicians, Lipitor's average detailing numbers increase to 0.81; and for high type physicians, the average number of detailing increases to 0.89. Based on the first difference results, the increase in detailing numbers for the median type physicians is 0.16, while the increase for low and high types physicians are 0.09 and 0.07 respectively. The

Dif-in-Dif estimates (0.07 and 0.09) suggest that Lipitor's detailing increases the most among median type physicians. However, due to the large standard error (0.18 and 0.24), we cannot conclude that the difference is statistically significant.

[Insert Table 3 Here]

A potential concern of the Dif-in-Dif study is the misclassification of median market. We define a physician to be median Crestor market if Crestor's market share is between the 25th and 75th quantile. If the median market is incorrectly specified, we may not make the correct comparison. In order to check if the definition of the median market affects our findings, we non-parametrically estimate the detailing level of Lipitor during the four weeks prior to and after the news event as a function of the quantile of Crestor market share.[12]

Figure 1 plots the nonparametric estimates of Lipitor detailing and the quantile of Crestor market share. The result shows that when Crestor's market share is between the 40th and 70th quantile, Lipitor increases the detailing level the most after the news event. For physician's whose Crestor market share is below 40th quantile or above 70th quantile, Lipitor's advertising level increases by a much smaller scale.

As the figure shows, the change in Lipitor advertising is non-monotonic in Crestor's market share. Moreover, the largest increase in advertising level happens for those physicians where Crestor's market share is in the median range (40th to 70th quantile).

[Insert Figure 1 Here]

[12]The Nadaraya Watson kernel regression estimator is:

$$\begin{aligned} m(x) &= \sum_{i=1}^{n} w_{ni}(x) y_i \\ w_{ni}(x) &= K(\frac{x_i - x}{h}) / (\sum_{i=1}^{n} K(\frac{x_i - x}{h})) \end{aligned}$$

where y_i is the observed number of detailings, x_i is the observed quantile of market share, and x is the value of quantile of market share where we calculate the expected number of detailings.

7 The Empirical Model and Results

Our baseline econometric model uses a regression based model to measure the impact of bad news about Crestor on changes in the detailing patterns of Lipitor. An advantage of a regression based model is that we can control for additional market characteristics. In addition, as we have a panel data of physicians, regression based model allows us to control for physician specific effect through random effect model and fixed effect model.

We use the market share of Crestor in the last month to categorize a physician. For example, for physicians we observe in February (week 5-8), we use their Crestor's market share in January (week 1-4) to determine physician's type. Again we use the quantile of Crestor's market share distribution to determine the market share ranges of Crestor. Based on the prescription data in week 1-4 (January) and week 5-8 (February), the 25th percentile of Crestor's market share is at 0.07, the median is at 0.11, and the 75th percentile is at 0.2. We choose to categorize a physician as Low, Median, and High if the market share of Crestor is between [0-0.07), [0.07-0.2], and (0.2, 1] respectively.

We begin with changes in Lipitor's detailing pattern both before and after the bad news event. The basic specification is as follows:

$$\begin{aligned} y_{it} &= \exp(\beta_0 + \beta_1 CM + \beta_2 CH + \\ &\quad (\gamma_0 + \gamma_1 CM + \gamma_2 CH) * Postevent + \delta X_{it} + \alpha_i) \end{aligned}$$

where y_{it} is the number of visits by Lipitor's sales representatives to physician i before (t=1) and after (t=2) the news event. It is a non-negative integer. Similar to the above Dif-in-Dif estimation, we use four weeks of window before and after the event. Thus t=1 if the week is between five and eight, and t=2 if the week is between ten and thirteen. CM and CH are dummy variables indicative of Crestor's market share in the median range and high range respectively during the previous four weeks. Namely, we use week 1-4 to create past market share for t=1 and week 5-8 to create past market share for t=2. Postevent

is a dummy variable equal to 1 for t=2. X_{it} are market characteristics that may affect the detailing decisions. These market characteristics include the market size, the share of new patients, the share of older patients (age 65+), the share of Asian patients, the share of female patients, and the share of severe-symptom patients. These additional variables, all are based on the lagged four weeks of data, help to control for other factors that might influence the demand for Crestor. α_i is the physician specific effect in the random effect model and fixed effect model. In all the regressions, we weight observations using the number of prescriptions of Statin drugs issued by the physician in weeks 1-8, in order that larger markets should have a greater impact on Lipitor's detailing response than smaller ones.

Table 4 gives the results from the baseline specification using random effect regression and fixed effect regression. We first report the regression results in specification 1 and specification 2, where we do not include X_{it} in the regression. The estimated coefficients of γ_0, γ_1, and γ_2 from the random effect models are 0.06, 0.07 and -0.13 respectively. All coefficient estimates are significant. The coefficients from the fixed effect model are 0.05, 0.05 and -0.11 respectively and only the estimates of γ_0 and γ_2 are significant. First, the estimates from both specifications are reasonably similar. They suggest that γ_0 and γ_1 are positive and γ_2 is negative. Namely, after the news event, advertising level for physicians with low and median Crestor market share increases; while it decreases for physicians with high Crestor market share. In addition, the magnitude of increase in the detailing intensity is the highest to those physicians for whom Crestor market share falls in the medium range.

Secondly, we report the regression results in specification 3 and specification 4, where we include X_{it} in the regression. The estimate of γ_0 is 0.05 in random effect model and 0.07 in fixed effect model. Estimates of γ_1 are 0.08 and 0.07 respectively for random effect and fixed effect model; while the estimates of γ_2 are -0.05 and -0.12. The estimates

from both specifications are similar. They both show that advertising level increases the most to physicians with median Crestor market share. This suggests that our findings are robust to additional control variables.

[Insert Table 4 Here]

If Lipitor's post-news advertising indeed has predatory intent, an interesting question is whether such intent is more pronounced in large markets, i.e, physicians with a large number of Statin drug prescriptions. On the one side, predatory intent can be stronger in large-size markets because Lipitor may profit more once Crestor exits. On the other side, advertising can be a less effective predation tool in large markets. Such markets likely attract a high volume of detailing from competing brands. Moreover, advertising may become less informative in large markets as those physicians can be more knowledgeable about drug efficacy from their prescription experiences. Therefore, the incentive for Lipitor to prey can be weaker in large markets as advertising becomes less effective.

To check whether predation intent is stronger in large markets, we separate the physicians into two categories, large market physicians and small market physicians. Since the average number of monthly Statin prescriptions in our sample is around 20, we define a market to be "small" if its monthly total prescriptions both before and after the news event are less than 20. Otherwise, we categorize it to be "large". This categorization leaves us with 152 small markets and 156 large markets.[13] We then estimate our baseline model on the two samples separately and the results are reported in Table 5.

[Insert Table 5 Here]

The top panel of Table 5 presents the baseline result for small market physicians. In specification 1 and specification 2, where we do not control for additional covariates in the

[13] Our empirical results are robust under alternative but similar definitions of large and small markets.

regression, the estimated coefficients of γ_0, γ_1, and γ_2 from the random effect models are 0.14, 0.15 and -0.28 respectively. All coefficient estimates are significant. The coefficients from the fixed effect model are 0.04, 0.47 and -0.15 respectively and only the estimates of γ_1 and γ_2 are significant. Secondly, we report the regression results in specification 3 and specification 4, where we include additional control variables in the regression. The estimate of γ_0 is 0.13 in random effect model and 0.08 in fixed effect model. Estimates of γ_1 are 0.18 and 0.5; while the estimates of γ_2 are -0.19 and 0.03 respectively. Estimates of γ_1 are both significant. The estimates from all four specifications are reasonably similar. They suggest that γ_0 and γ_1 are positive and significant while estimates of γ_2 are either negative or insignificant.

Comparing with the results using the full sample, we find that, qualitatively the change in Liptior's advertising in small markets shows a similar pattern. Namely, after the news event, Lipitor advertising increases the most among physicians for whom Crestor market share falls in the medium range. Moreover, such a non-monotonic change in Lipitor's advertising is more prominent in those smaller markets, as the estimates of γ_1 in the top panel of Table 5 are all highly significant and larger than the estimates in Table 4.

Interestingly, we could not find a similar change in Lipitor's advertising patterns for large markets, shown by the bottom panel of Table 5. The estimated coefficients of γ_1 in the two random effect models (specification 1 and 3) are negative and insignificant at -0.01 and -0.02; while in the two fixed effect models (specification 2 and 4), the estimates of γ_1 are negative and significant at -0.2 and -0.22 respectively. As such, in large markets, Lipitor does not increase its advertising intensity the most among physicians with medium Crestor market share.

The results of Table 5 show that, Lipitor's predatory intent is even stronger among smaller markets. While other interprets can exist, this finding is consistent with the argument of diminishing marginal effect of advertising.

8 Testing for Alternative Explanation

The above empirical part looks at the changes in advertising patterns of Crestor's major competitor, Lipitor, before and after the news event. The results suggest that the change in advertising is non-monotonic in the prior demand for Crestor. Moreover, Lipitor increases the advertising intensity the most among physicians with median Crestor market share. The above findings are consistent with the prediction of Chen and Tan (2009), which argue that Crestor's competitors' advertising can be predatory in the post-shock period.

It is worth mentioning that Chen and Tan (2009) provide a possible explanation of predation based on signaling game. There can be other possible explanations of predation. However, the idea that predation is either unnecessary or impossible in markets where the demand for Crestor is too low or too high is likely to be true with those other explanations of predation. Therefore, our empirical results can be consistent with those alternative models on predation.

As pointed out in section 4, the change in Lipitor's advertising could be non-monotonic even if Lipitor takes a normal competitive response, i.e., it is maximizing post-news profit without caring about Crestor's future exit decision. In this section, we use several additional tests to explore the possibility of this alternative explanation.

Firstly, since the news only affects Crestor but not other brands of Statin drug, Lipitor's detailing towards other brands should be at normal competitive level. If Lipitor's advertising has predatory intent towards Crestor after the news event, we expect that the non-monotonic change in Lipitor's detailing only happens to physicians where Crestor has median market share, but not to physicians where other brands have median market share.

Secondly, we expect the two smaller brands, Zocor and Pravachol, with patents expiring soon, have much weaker incentive (if existing at all) to engage in predatory practice compared with Lipitor. Their post-shock advertising should mainly capture the normal

competitive response to the bad news. Thus changes in their advertising patterns should be different from that of Lipitor.

We follow the same approach as in Section 6 and 7. We begin with a Difference-in-Difference study, where we compare the difference in detailing intensity between comparison group and control group before and after the news event. We then use a regression based estimator which allows us to control for additional variables.

8.1 Change in Lipitor's Advertising and Pravachol's Market Share

As argued above, we do not expect Lipitor to use predatory strategy against other Statin drugs. Since Pravachol's market share is the closest to that of Crestor, we choose to examine whether Lipitor increases the advertising intensity the most among physicians with median Pravachol market share.

We report in Table 6 the results of a Dif-in-Dif study using Pravachol's market share to construct comparison group and control group, while Liptior's detailing is still the outcome variable. Namely, the comparison group includes physicians whose prescription level of Pravachol falls in the median range. For the control group, we use physicians with low prescription level of Pravachol and physicians with high prescription level of Pravachol.

After the news event, average detailing number of Lipitor to physicians with median market share of Pravachol increases from 0.82 to 0.90; while its detailing increases from 0.75 to 0.93 for physicians with low market share of Pravachol and from 0.64 to 0.69 for physicians with high market share of Pravachol. Thus Lipitor's detailing intensity shows a much larger increase within physicians where Pravachol has low market share, instead of within physicians where Pravachol has median market share. The Dif-in-Dif estimates are -0.10 and 0.03, with the first value negative.

[Insert Table 6 Here]

Figure 2 plots the nonparametric estimates of Lipitor detailing and the quantile of Pravachol market share. As the figure shows, for physicians with low Pravachol market share, Lipitor's advertising increases the most after the news. The changes in Lipitor's detailing strategies towards Crestor are different with what they are towards Pravachol. This finding provides evidence that the upward distortion in Lipitor's detailing to the median type of physicians for Crestor is unlikely a result of a pure competitive response to the bad news.

[Insert Figure 2 Here]

8.2 Change in Zocor/Provachol's Advertising and Crestor's Market Share

Compared with Lipitor, the second and third best seller of Statin drug, Zocor and Pravachol, have a much smaller market share and their patents are expiring soon at the point of the bad news. Thus their predatory intent, if exists at all, should be much weaker compared with Lipitor. We run two additional Dif-in-Dif estimations by replacing the outcome variable in the baseline model (Table 3) with the detailing levels of Zocor and Pravachol respectively. The comparison group and control group are constructed in the same way by using Crestor's market share.

The results are included in Table 7. The mean number of Zocor's detailing within physicians with median, low and high market share of Crestor is 0.81, 0.72, and 0.79 before the news event; and it increases to 0.94, 0.98 and 1.07 after the news event. The increases in Zocor's detailing are higher among physicians where Crestor has low and high market share (0.26 and 0.28). The Dif-in-Dif results are both negative (-0.13 and -0.15) for Zocor. Moreover, changes in Pravachol's detailing patterns differ from that of Lipitor as well. The mean number of Provachol's detailing within physicians with median,

low and high market share of Crestor is 0.60, 0.49, and 0.43 before the news event; and it changes to 0.77, 0.47 and 0.66 after the news event. The Dif-in-Dif estimates are 0.2 and -0.06 respectively, indicating that changes in Pravochol's detailing patterns is monotonic in Crestor market share.

[Insert Table 7 Here]

One may argue that the uniqueness in the change of Liptior's advertising patterns is more related to its large market share among the whole sample. Therefore, we also check Zocor and Provachol's response to the bad news within the markets where they have relatively high market share. In the reduced sample for Zocor, we use markets where Zocor's market share in week 1-8 is above its median level (24 percent); while the reduced sample for Pravachol include only markets where Pravachol's market share in week 1-8 is above its median level (11 percent). Table 8 presents the Dif-in-Dif results using reduced samples. Comparing with Table 7, we find that the results with reduced samples are qualitatively the same. The Dif-in-Dif results are both negative (-0.13 and -0.23) for Zocor, while for Pravachol, the Dif-in-Dif estimates are 0.21 and -0.13 respectively. Thus the changes in Zocor and Pravochol's detailing patterns differ from that of Lipitor even among those markets where they take a relatively large market share.

[Insert Table 8 Here]

Figure 3 and Figure 4 present the result of nonparametric estimates of Zocor and Pravachol's detailing level. Compared to Lipitor, Zocor and Pravachol clearly have different changes in detailing patterns after the news event. The most significant increase in Zocor's detailing happens to physicians with high and low Crestor market share, while the most significant increase in Pravachol's detailing happens to physicians with high Crestor market share.

[Insert Figure 3 and Figure 4 Here]

We then use a regression model to look at the changes in Zocor and Provacor's detailing. We replace the dependent variable in the baseline model with the respective numbers of visits by Zocor and Pravacor sales representatives to physicians. Table 9 gives the results using the random effect and fixed effect model. The top panel reports the results using number of Zocor's detailing as outcome variable. In specification 1 and 2, we do not include additional control variables. According to the random effect model (specification 1), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.23, -0.14 and 0.05 respectively. The coefficients of γ_0 and γ_1 are significant. According to the fixed effect model (specification 2), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.26, -0.14 and -0.09 respectively. All are significant. In specification 3 and 4, we include additional control variables. According to the random effect model (specification 3), the estimated coefficients of γ_0, γ_1, and γ_2 are all significant at 0.21, -0.14 and 0.17 respectively. According to the fixed effect model (specification 4), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.26, -0.01 and 0.08 respectively. Only the estimate of γ_0 is significant. It is clear that Zocor does not increase its detailing the most among physicians where Crestor has median market share, as the estimates of γ_1 are either negative or insignificant across all specifications.

The bottom panel of Table 9 reports the results using number of Pravachol's detailing as outcome variable. In specification 1 and 2, we do not include additional control variables. According to the random effect model (specification 1), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.07, 0.02 and 0.36 respectively. The coefficients of γ_0 and γ_2 are significant. According to the fixed effect model (specification 2), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.09, -0.09 and 0.41 respectively. All are significant. In specification 3 and 4, we include additional control variables. According to the random effect model (specification 3), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.05, -0.02 and 0.43 respectively. The coefficients of γ_0 and γ_2 are significant. According to the fixed effect

model (specification 4), the estimated coefficients of γ_0, γ_1, and γ_2 are 0.1, -0.09 and 0.47 respectively. The coefficients of γ_0 and γ_2 are significant. In all four specifications, the estimates of γ_1 are either negative or insignificant, while the estimates of γ_0 and γ_2 are positive and significant. This suggests that Pravachol increases advertising intensity more to physicians with high Crestor market share.

[Insert Table 9 Here]

To summarize, both the Dif-in-Dif study and regression results show that the changes in the advertising patterns for the two smaller competitors of Crestor, Zocor and Pravachol, differ in a significant way from that of Lipitor. We do not find a significant increase in Zocor/Pravachol's advertising intensity among physicians with median market share of Crestor.

The additional results from the empirical tests above suggest that, the upward-distortion in advertising among physicians with median Crestor market share is unique with Lipitor. This finding can hardly be justified by the hypothesis that Lipitor takes a normal competitive response to the bad news. Instead, the prediction based on predation as described in Section 4 better explains the empirical findings.

9 Conclusion

We study the advertising behavior of Crestor's competitors following a petition of withdrawal of Crestor. Our empirical work shows that, the advertising of Crestor's major competitor, Lipitor, exhibits certain pattern which differs in a significant way from Crestor's other competitors. To be explicit, we find that Lipitor increases its advertising the most among physicians where Crestor has taken a median share in total prescriptions. More-

over, such changes in advertising patterns are not found with the second and third seller, Zocor and Pravachol. Neither does Lipitor shows a similar change in its advertising with physicians where other Statin drugs take a median market share.

The empirical findings cannot be easily explained if Lipitor's post-shock advertising is a normal competitive response. Chen and Tan (2009) develop a model based on predation which offers an explanation. They show that, under asymmetric information between Lipitor and Crestor, in equilibrium Lipitor increases its advertising in order to signal Crestor an unprofitable market, with an eye towards Crestor's future withdrawal. Moreover, the upward distortion in Lipitor's advertising occurs only among physicians where Crestor has taken median market demand, since for the rest physicians, it is either unnecessary or impossible for Lipitor to induce the exit of Crestor. Our empirical results are supportive to the predictions in Chen and Tan (2009).

Although there is an extensive theoretical literature on the use of predatory strategies, empirical study on predation is still rare. One of the reasons for the lack of empirical work may rely with the fact that, it is usually hard to differentiate a predatory behavior from a normal competitive behavior. Our approach is based on the "natural experiment" method. Since the news event is an exogenous change to the market situation, we can identify predatory intention by comparing the changes in firm's strategy from before to after the news across different markets where the incentive to prey varies.

A caveat in interpreting our empirical findings is that, a normal competitive response of Lipitor to the bad news could generate a similar post-news advertising pattern, which we could not completely rule out. Nevertheless, our additional tests argue against this alternative explanation. Future work is warranted to further differentiate predatory behavior from normal competitive behavior.

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