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The financial impact of product recall announcements in China

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ABSTRACT

A product recall can be viewed as a firm's worst nightmare. Although the long-term damage to brand equity and company reputation may be difficult, if not impossible, to quantify, the short-term impact on shareholders' wealth is readily estimable. While many studies have examined this issue in the Western context, little is known about the financial impact of a product recall announcement in China. To advance the knowledge about the financial impact of a product recall announcement, we explore this issue using event study methodology. In general, our findings are congruent with previous research that product recalls result in negative abnormal returns. Interestingly, however, we found that Chinese companies suffered from greater financial losses than their Western counterparts did. This study also provides evidence that the Chinese food industry experiences a more severe stock market reaction than the automobile industry and that a passive recall strategy was associated with a more negative stock market reaction than a proactive recall strategy. We conclude with several future research avenues for global research on product recalls.

1. Introduction

The recent surge in product recalls of Chinese-made products has attracted substantial attention from government and academia, due to their danger to consumers. In Europe, 50% of the product risk notifications in 2005 were related to products from China (European Commission 2005). Statistics announced by the Consumer Product Safety Commission of the US (2007) (www.mondag.com/article.asp?articleid=57594) show that 67% of all product recalls came from Chinese-manufactured products. Thus, product safety in China has become a knotty issue that awaits disposition. For the first time, food and drug safety issues were the topic of Chinese government report in 2009, pointing out that "The government will implement strict market access rules and product traceability and recall systems so that the people buy food and drugs with confidence and consume them with satisfaction." (Wen, 2009). The "Food Safety Law of the People's Republic of China" has been in effect since June 1, 2009, emphasizing inspection for food safety in all tiers, from farm to fork. This action signifies that the Chinese government has decided to pay close attention to product safety issues and thus places substantial value on the enhancement of product quality.

A product recall is an example of a product-harm crisis, which is defined as a "discrete, well-publicized occurrence wherein products are found to be defective or dangerous (Dawar and Pillutla, 2000, pg. 215)". Product harm crises have been increasing in frequency, which has been attributed to globalization, increasing complexity of products and higher consumer demand, as well as more stringent product safety legislation (Dawar and Pillutla, 2000; Karipidis, 2011). Product harm crises and subsequent product recalls are "among a firm's worst nightmares (Heerde et al., 2007, p. 230)," because they cause consumer panic and are very costly, as seen in the recent case of the Sanlu group, which was at the center of the Chinese melamine-tainted milk powder crisis, which filed for bankruptcy proceedings due to the mounting health liability claims associated with its defective milk powder. Product recalls cannot only ruin carefully cultivated brand equity and tarnish a company's reputation, but they can also result in major revenue and market-share losses (Chen et al., 2009).

Although estimating the long-term damage of product recalls on brand equity and company reputation is difficult, if not impossible, the short-term impact on shareholder wealth is nevertheless estimable through the use of event study methodology. The underpinnings of event study methodology state that, in an efficient market, the financial impact of an unanticipated event will be immediately reflected in stock prices (Fama, 1970). Since a product recall is an important unanticipated economic event, the study of the shareholder wealth effect of product recalls provides a good understanding of the efficiency of stock markets (Pruitt and Peterson, 1986). While there is a substantial body of research which has discussed and examined the short-term impact of a

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product recall on shareholders' wealth in a Western context (Jarrell and Peltzman, 1985; Pruitt and Peterson, 1986; Hoffer et al., 1988; Bromiley and Marcus, 1989; Davidson and Worrell, 1992; Thomsen and McKenzie, 2001; Govindaraj et al., 2004; Chu et al., 2005; Cheah et al., 2007; Chen et al., 2009), mostly providing evidence in support of the efficient market hypothesis, little is known about the impact of a product recall announcement in the Chinese stock market. This is important because of China's emerging economy. Many consumer products and components are produced in supply chains that extend through emerging economies, thus this topic has implications in China, as well as in the developed world. In addition, the number of consumers in China is very large, and developing a better understanding of their reaction to recall announcements contributes to the study of supply chain quality. Furthermore, if a company does experience a product-harm crisis and subsequent recall, it is important to effectively craft a recall strategy to mitigate the potential negative effects.

In order to advance the knowledge about the impact of product recalls in China, we investigated the stock market reaction to a product recall announcement, based on publicly listed companies in China. We used event study methodology and compared our findings with those from previous studies that examined publicly listed companies in Western stock markets. We also examined the companies' posture towards supply chain product-harm crises and subsequent product recalls, investigating whether the stock market would react differently depending on the recall strategy followed by affected companies in announcing the recall.

The remainder of the paper is organized as follows. The literature is reviewed and the hypotheses are developed in Section 2. The research methodology and data analyses are described in Section 3. Section 4 discusses the empirical results. Concluding remarks and suggestions for further research are presented in Section 5.

2. Theoretical background and research hypotheses

2.1. Financial impact of a product recall

A product recall, like other types of negative publicity, can severely damage a firm's image, and even worse, destroy investors' confidence, which will be reflected in the decline of its stock price. Although the long-term damage to brand equity and company reputation associated with a product recall may be difficult, if not impossible, to quantify, the short-term impact on shareholders' wealth is readily estimable through the use of event study methodology, based on daily stock prices. Event study methodology is a well-established approach that has been used in numerous academic papers to measure the financial impact of unanticipated corporate events, such as supply chain glitches (Hendricks and Singhal, 2003), and the announcement of quality award winners (Wright et al., 1995), ISO9000 (Lo et al., 2009).

Prior researchers have examined the short-term effects of a product recall announcement on the stock prices of affected companies, based on product recalls in the United States (Jarrell and Peltzman, 1985; Pruitt and Peterson, 1986; Hoffer et al., 1988; Bromiley and Marcus, 1989; Davidson and Worrell, 1992; Thomsen and McKenzie, 2001; Govindaraj et al., 2004; Chu et al., 2005; Cheah et al., 2007; Chen et al., 2009). These studies have revealed that, in general, a significant decline in stock price followed a product recall announcement. For example, Jarrell and Peltzman (1985) found that the shareholders of firms producing recalled drugs and automobiles bore financial losses that exceeded the direct costs of recalling the defective products. Much of the prior research on the stock market reaction to a product recall announcement has focused on recalls in the automotive industry (Hoffer et al., 1987; Reilly et al., 1983; Rupp, 2001; Rhee and Haunschild, 2006; Haunschild and Rhee, 2004), however, other notable studies have focused on pharmaceuticals (Dowdell et al., 1992) and tires (Govindaraj et al., 2004). Hendricks and Singhal (2003) studied the effect on stock price associated with supply chain disruptions, in general, which included product recalls across industry types as one type of supply chain disruption.

There has been some debate in previous event studies about the size of the stock market reaction to a product recall announcement. Hoffer et al. (1988) found "little evidence" of a significant effect for a recall firm, after correcting some methodological problems and reclassifying and reanalyzing Jarrell and Peltzman's (1985) data for the 1975–1981 period. Bromiley and Marcus (1989) found that the negative stock market reaction to defective automobile recalls was too small to prevent producers from providing defective automobiles, compared to the expected potential gains from providing these defective products.

As a baseline, we propose:

H_1: A product recall announcement is associated with a negative abnormal return on stock price.

2.2. Signaling effect of recall strategy

Investors may react differently to news of the discovery of a product hazard, depending on the actions and strategies followed by the responsible companies. Beyond the publicly available information contained in the recall announcement, companies take different actions, in terms of when to announce a recall and how to handle it. For example, Siomkos and Kurzbard (1994) divided company responses to a product hazard into four categories: denial, involuntary recall, voluntary recall and super-effort, comprising the "company response continuum." It is important to understand consumer and market reactions to different recall strategies, in order to effectively craft a suitable recall strategy to mitigate the potential negative effects of a product recall announcement (Siomkos and Kurzbard, 1994; Rupp, 2001; Orlitzky et al., 2003; Chen et al., 2009).

Researchers have argued that the stock market reaction to a product recall announcement may vary considerably, depending on the information content of the recall announcement. This is supported by signaling theory (Connelly et al, 2011), which posits that the market interprets an event in terms of the signal that it sends about the quality of a good or service. Buyers and sellers possess asymmetric information about product quality for items that are high in experience qualities; the quality of an item that is high in experience qualities can only be evaluated after it has been purchased and consumed. In the absence of complete information about product quality (Boulding and Kirmani, 1993), consumers form their own "intuitive theories" (Wright, 1986, p.1) about the quality of a product they are considering purchasing. In order to send a high quality message about their products, sellers may rely on signals such as price (Zeithaml, 1988), advertising (Kirmani, 1990; Kirmani and Wright, 1989) or warranties (Kelley, 1988; Wiener, 1985). Based on such signals, consumers form their impressions of the quality of the products that are offered (Beales et al., 1981), prior to purchase.

In the case of a product hazard, the sellers may know about the existence of the hazard, as well as its severity and pervasiveness, but potential buyers do not. A seller which has discovered a minor, non-pervasive product defect may be motivated to accurately inform potential buyers about it, so that it can appropriately compensate the buyers. Thus, buyers may interpret a proactive recall announcement as a signal of a minor, non-pervasive hazard. In contrast, a seller which has discovered a serious, pervasive product defect may prefer to deceive the buyer about the unobserved quality of the product, in order to capture undeserved returns in the marketplace. Because of the pervasiveness or severity

of the hazard in its products, the seller could not profitably repair or replace all of the defective items, thus it would avoid a proactive recall announcement, only recalling its products if forced to do so by a government agency. Thus, consumers and the market may interpret a proactive recall strategy as the signal of a minor, non-pervasive defect, while a passive recall strategy may be interpreted as signaling a serious, pervasive and costly defect, which will have serious implications for the seller's future revenue stream.

The empirical evidence about the signaling effect of proactive versus passive recall announcements is mixed, and there are two schools of thought about the meaning of the signal that a proactive recall announcement sends. Rupp (2001) divided recall strategies into government-initiated and manufacturer-initiated recalls, with findings that supported the notion that different product recall strategies have differing impacts. Davidson and Worrell (1992) found that more significantly negative abnormal returns were strongly associated with recall announcements for replacing or returning purchases, compared with announcements of recalls for repair or checking of products. Similarly, Thomsen and McKenzie (2001) found that recalls for products with a more serious hazard were associated with significant negative losses, while recalls for products with a less serious hazard had no negative impact. Davidson and Worrell (1992) found that government-ordered recalls were associated with greater losses in shareholder value than voluntary recalls.

However, Chen et al. (2009) found that a proactive product recall announcement made before a required recall by the Consumer Product Safety Commission had a more negative effect on a firm's financial value, when compared to passive strategies. They interpreted this as investors perceiving a proactive strategy as a signal of larger impending financial losses to the firm, rather than signaling a minor hazard or socially responsible actions by the firm. Similarly, Rupp (2001) found that recalls initiated by the government were not found to be associated with greater shareholder losses.

There are also corporate social responsibility implications of employing a proactive versus passive recall strategy. Jolly and Mowen (1984) indicated that a company is perceived to be more responsible if it acts before a government agency steps in and orders it to take action. By issuing a proactive recall, the company sends a signal that it sincerely cares about the health and safety of its customers, and that these concerns are more important to it than any revenue implications associated with recalling hazardous products. Hence, people may perceive a recall announcement as a signal of socially responsible actions to proactively prevent potential hazards, rather than potentially leading to substantial financial losses for involved companies (Siegel and Vitaliano, 2007). Many U.S. product recall announcements are made before there are any reports of accidents or injuries. Thus, people in the U.S. may perceive a proactive product recall as a signal of a firm's diligence in attending to quality issues and believe that socially responsible firms are more likely to produce high-quality products (Siegel and Vitaliano, 2007). This enhances consumers' confidence in the firm's products and results in an increase in future sales and revenue, which helps to relieve the negative impact of the stock market reaction to a product recall announcement (Siomkos and Kurzbard, 1994; Margolis et al., 2007).

Thus, we hypothesize:

H_2: A passive product recall strategy will be associated with a more negative standardized abnormal return than a proactive product recall strategy.

2.3. Effect of industry

Another important issue in the study of product recalls is whether there are differences by industry in product recall strategies and their impact on shareholder wealth. Pruitt and Peterson (1986) found a significant negative financial impact of non-automobile product recalls on the equity holders of affected firms. Chu et al. (2005) studied the impact of security price reactions to product recalls in a different time period from that of Pruitt and Peterson (1986), finding that the drug and cosmetics industries suffered more, while the rubber and automotive industries were less affected.

In order to study potential industry differences, we focus on the automobile and food industries, which have very different characteristics. The automobile industry has been extensively studied in the prior literature on product recalls, which is based in the U.S. Automobiles are a considered to be luxury good in China, where only 38 of every 1000 people owned automobiles in 2008, compared with 500 of every 1000 people in developed countries (http://news.xinhuanet.com/video/2009-03/06/content_10956617.htm). The Chinese automobile industry is comprised of a few large automakers, which produce cars in high volumes on assembly lines. Many Chinese automobile companies cooperate with foreign companies. For example, First Automotive Group Corporation has cooperative relationships with international leaders such as Volkswagen AG, Toyota and Mazda, and Chana Auto Co. Ltd. has joint venture relationships with Ford, Mazda and Suzuki. In contrast, the food industry is broad, encompassing the agriculture, manufacturing and service industries. It contains long supply chains, from farming to processing and sales.

We expect that there will be fundamental differences in product recall strategies and their effect between companies in the automobile and food industries in China, for several reasons. First, the Chinese automobile industry has more experience with product recalls. Because recall systems have existed in the Chinese automotive industry since 2004, systems for managing automobile product recalls are more mature than they are in other industries in China. Government legislation, joint ventures with international partners and promotion have caused more automobile companies follow proactive recall strategies; government regulation is one of the most important driving forces for coercive isomorphism (DiMaggio and Powell 1983; Ketokivi and Schroeder, 2004; McFarland et al., 2008). In contrast, recall systems for food recalls in China were not set up until 2007. The systems are much less mature, leading to food recalls tending to be issued only when there are consumer complaints or incidents (passive recalls). Previous recalls for food products in China have always been in response to health-related incidents.

Second, food is ubiquitous. Because food is a necessity, rather than a luxury, everyone is affected by defective food products. While defective food products can lead to serious and immediate health issues, defective automotive parts seldom do. In addition, food products are much less associated with brand than automobiles are. For example, in the recent recalls of contaminated raw spinach in the US, consumers found it very difficult to identify the supplier of their spinach, which resulted in an overall boycott of all raw spinach. Even for branded products like baby formula, consumers cannot readily identify the farm that supplied the potentially contaminated raw milk products. In contrast, during Toyota's recent quality problems, consumers had no difficulty identifying the affected brand and models and where they were made.

Third, Chinese automobile companies are more aware of the potential impact of a product hazard than food companies, because of their strong relationships with foreign manufacturers. Firms which are embedded in social networks are inclined to imitate the behaviors of other network members (Henisz and Delios, 2001; McFarland et al., 2008). Due to mimetic isomorphism, firms not only imitate the organizations they perceive as successful in their industry, but they are also more likely to

imitate those organizations with which they have social ties (Galaskiewicz and Wasserman, 1989; Lo et al., 2011). Thus, Chinese automobile companies have learned a lot from the leading international automobile companies that they have relationships with, including corporate social responsibility for proactively dealing with product hazards. In contrast, Chinese food companies are much more local and regional in focus, tending to both purchase supplies and distribute products exclusively in China. They are less aware of the potential impact of a product hazard due to defective food products.

Fourth, structural differences between the automobile and food industries are associated with differences in strategies for dealing with product hazards. Entry barriers are relatively high in the automotive industry (http://report.cei.gov.cn/doc/zh14/2005012024341.pdf). Automobile companies are large, and their "suppliers (are) bigger and have more resources,…and the supply-network structure … take (s) on a more formalized face that comes with the more standardized configurations of the work procedures of ERP (Choi and Hong, 2002, pg. 490)." In addition, automobiles are discrete products, and each automobile has a unique identification number (VIN), making it potentially easier to recall particular automobiles and to identify the specific automobile that contains a hazardous component. Because of their sophisticated information systems and discrete, uniquely identifiable products, it is relatively easy for automobile companies to develop and use systems for defect traceability and process control. Thus, we propose that automobile companies are more willing to employ proactive recall strategies.

However, the situation in the food industry is quite different. There are many tiers in food production supply chains "from farm to fork," and the barriers to entry by farmers are quite low. For example, batches of raw milk produced by dairy farmers with different quality attributes are often mixed together in milk collection stations, which increases the complexity of tracing back to the source (Wang et al., 2009, 2010), and milk is typically monitored in batches, instead of as uniquely identified items (Jansen-Vullers et al., 2003). Hence, when a hazardous food product is discovered, it is very difficult to "trace and follow food, feed and ingredients through all stages of production, processing and distribution" (Wang et al., 2009, pg. 2866), which potentially increases the number of recalled products. This makes it very difficult or impossible to track and trace back to the source of the problem (Tse and Tan, 2012), especially those raw materials bought from spot market (Han et al., 2011). For example, in the 2008 melamine-tainted milk crisis in China, more than 70% of raw milk was provided by small-scale farmers, some of whom were as small as owning a single cow, who were scattered across the country, and gathered through independent milk collection stations (http://news.xinhuanet.com/newscenter/2009-03/23/content_11059245.htm). Many small dairy farmers in China are illiterate and do not keep feed, medication and yield records for individual cattle. Because the raw milk provided by the individual farmers had been intermingled in the collection station vats, it was impossible to identify the source of the contaminated raw milk. Because of such difficulties, the Chinese food industry is reluctant to employ proactive recalls.

H_3: There are differences between industries in the use of proactive versus passive product recall strategies.

We also hypothesize recalls in the food industry have a greater negative impact on public perceptions of a firm, for many of the reasons listed above. Food recalls are perceived as being more serious financial events because of the ubiquitous nature of food, difficulties in tracing defects to their source and the fact that Chinese food product recalls have always been in response to illness reports. These signal more serious financial repercussions for the food products producers. For example, after the 2008 melamine-tainted milk crisis, many Chinese people stopped purchasing all Chinese dairy products.

In contrast, the impact of an automobile recall in China will not be as large as that of a food recall. Because cars are considered a luxury item, many Chinese people do not own a car, although they all eat food. Because many Chinese automobile recalls are made before there has been an accident or injury, people interpret automotive recalls as a signal of socially responsible action and automakers' diligence in attending to quality issues, rather than as a signal of impending financial losses, which mitigates the negative consequences by stock returns on product recalls. Hence, investors perceive a food product recall as a more serious signal of impending financial loss for the affected firm, compared with an automobile recall.

H_4: A product recall announcement in the food industry will be associated with a more negative standardized abnormal return than one in the automotive industry.

3. Methodology

3.1. Data

We selected product recall announcements for companies whose common stock was listed on either the Shenzhen A Share Stock Exchange or the Shanghai A Share Stock Exchange. We searched for product recall announcements from several sources, using "recall," "return," "replace" and "take off the shelf" as key words. The sources included four Chinese major security newspapers, including *China Security Journal*, *Shanghai Securities News*, *Securities Daily* and *Secutimes*, which have been designated by the *China Securities Regulatory Commission* (CSRC) to release news about Chinese listed companies. We also collected product recall announcements from the China Infobank database (http://www.infobank.cn/), which houses basic materials, important decisions, announcements and reports about Chinese companies listed in the Shenzhen Stock Exchange and Shanghai Stock Exchange from 1993 to the present, and the website www.cninfo.com.cn, which is the official website designated by the CSRC to release news about Chinese publicly listed companies. A third source was the Chinese automobile recall website (http://www.qiche365.org.cn/), which was set up to release automobile recall news, as part of the automobile recall system established by the Chinese government in 2004.

There were a total of 42 product recall announcements covering the ten year period from 2002 (the first product recall for a Chinese publically traded company) to March of 2011, among which twenty announcements were in the automobile industry[1], eleven were in the pharmaceutical industry, six were in the food industry and five were in the electronics industry. Table 1 provides examples of some representative cases. The year and industry distribution of the 42 recall announcements are shown in Fig. 1, and descriptive statistics are contained in Table 2. We used the data for the most recent fiscal year completed before the release of the product recall announcement.

[1] The twenty recall announcements in automobile industry were announced by eight different firms. Five of these eight different firms announced more than one recalls. For each distinct firm, if there are multiple recall announcements in the same year, we only use the first recall announcements.

Table 1
Representative product recall announcements in China.

Industry	Company	Year	Description
Automobile	FAW Car Co., Ltd.	2004	First recall in the Chinese automobile industry since the Chinese government released its "Defective Automobile Product Recall Regulations" in 2004. It recalled all Mazda6 produced before March 25, 2004 because the design for the gap between the insulation device of the fuel tank and the exhaust pipe were not large enough, hence might cause the fuel tank to be out of shape or melt.
	Dongfeng Automobile Co., Ltd	2007	Recall of the cars produced from during Sept. 7 to Sept. 21 because of the a potential risk that the brake fluid might ooze and influence the braking effect.
Food	Yili Industrial Group Co., Ltd.	2008	Recall of tainted produced milk powder and liquid milk products that used the industrial chemical melamine to artificially increase the protein level, after Chinese authorities reported the inspection results. Melamine-tainted milk products can be fatal for humans.
	Shuanghui Investment & Development Co., Ltd.	2011	Recall of tainted pork products contaminated with an illegal animal feed additive Clenbuterol, better known as "lean meat powder" to artificially lower the fat content. This is banned as a food additive because it can be fatal for humans.
Electronics	Elec-Tech International Co., Ltd	2005	Recall of juicers sold by Applica Consumer Products Inc. in the U.S. market. There was a potential risk that the blade might be broken as the juicer operated, with the result that there could be accidents that cause serious harm to the consumers as they drink the juice containing the broken blades.
	Tsinghua Tongfang Co., Ltd	2002	Recall of defective repeaters. This announcement initiated recall systems in the electronics products of this brand, which was the first recall in Chinese electronics industry.
Pharmaceuticals	Yabao Pharmaceutical Group Co., Ltd.	2007	Recall and destroy the "Alginic sodium diester injection," according to "Good Manufacturing Practice".
	Taiji Industry Company Ltd.	2010	Recall one kind of slimming products named "Qumei" that contained the banned Sibutramine ingredient, which can cause cardiovascular and cerebrovascular diseases in humans.

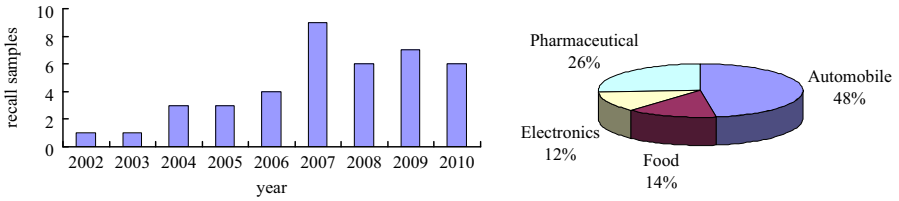

Fig. 1. Year and industry distribution of Chinese recall announcements.

Table 2
Sample demographics.

Measure	Mean	Median	Std. dev.	Maximum	Minimum
Sales (million RMB)	7420.61	3910.79	8609.81	36749.34	35.5
Total assets (million RMB)	6382.61	4201.15	6140.4	24471.42	134.46
Net profit (million RMB)	235.11	81.14	398.26	1450.68	−587.6
Employees	6341	5053	6861	40231	110

3.2. Analysis

We used event study methodology, based on daily security prices, to estimate the impact of a product recall announcement on shareholder wealth. Event study method is "a powerful tool that can help researchers assess the financial impact of changes in corporate policy (McWilliams and Siegel, 1997, pg. 626)". Using this method, we can determine whether there was an abnormal return on the security associated with an unanticipated event, such as a product recall announcement. We employed the following steps:

Step 1: Obtain the estimated parameters for computing the expected normal return of stock *i* on day *t*.
There are three ways to estimate normal returns, including mean-adjusted, market-adjusted and market model measures. We use the market model to estimate the normal returns associated with product recall announcements on shareholder wealth, in order to isolate the impact of market-related factors and control systematic risk (Hendricks and Singhal, 2003; Govindaraj et al., 2004). The market model uses the following equation as the basic framework for expressing the relationship between a firm's stock return and the market return:

$$R_{it} = \alpha_i + \beta_i \times R_{mt} + \varepsilon_{it} \quad (1)$$

where R_{it} is the actual return of stock i on each day t of estimation period $[t_0,t_1]$, R_{mt} is the return of market portfolio (such as Shanghai Composite Index or Shenzhen Composite Index) on each day t of estimation period $[t_0,t_1]$, α_i is the intercept of the relationship for stock i, β_i is the slope of the relationship of stock i with the market return, and ε_{it} is the error item with $\mathrm{Exp}(\varepsilon_{it}) = 0$, $\mathrm{Var}(\varepsilon_{it}) = S_i^2$.
We estimated α_i, β_i and S_i^2 through the use of ordinary least squares (OLS), over an estimation period of 120 trading days. We set the day of the product recall announcement to be day 0 and, consistent with most event studies, we used a 2-day event period, including both day 0 and day 1, to control for confounding effects (McWilliams and Siegel, 1997). The estimation period ended ten trading days before the recall announcement, that is, the estimation period was day $(-130, -11)$, in order to separate the estimation period and the event period, so as to isolate the impact of the event and prevent any potential bias (Hendricks and Singhal, 2003).

Step 2: Compute the normal return of stock *i* on each day *t* of the event period.
We used the estimates α_i, β_i and S_i^2, obtained in step 1, to compute the normal return of stock i on each day t of the event period.

$$E(R_{it}) = \alpha_i + \beta_i \times R_{mt} \quad (2)$$

Step 3: Compute the abnormal return (*AR*) of stock *i* on each day *t* of the event period.
The abnormal return measures the impact of the unanticipated information release on the security price. We derived estimates of the daily abnormal return (AR) for the ith company as

Table 3
Event study results.

Day	Abnormal return			Cumulative abnormal return		
	Mean	Median	(%) Negative	Mean	Median	(%) Negative
−5	−0.12% (0.68)	−0.77% (−0.857)	57.14% (0.926)	–	–	–
−4	0.63% (1.33)	0.25% (−1.358)	42.86% (−0.926)	–	–	–
−3	0.40% (0.88)	−0.19% (−0.644)	52.38% (0.309)	–	–	–
−2	0.38% (0.87)	0.24% (−0.600)	47.62% (−0.309)	–	–	–
−1	−0.21% (−0.57)	−0.59% (−0.275)	52.38% (0.309)	–	–	–
0	−0.31% (−0.84)	−0.01% (−0.724)	53.85% (0.480)	−0.31% (−0.84)	−0.01% (−0.724)	53.85% (0.480)
1	**−2.21%** (**−5.21*****)	**−1.52%** (**−3.964*****)	**78.57%** (**3.703*****)	**−2.52%** (**−4.404*****)	**−2.14%** (**−3.409*****)	**73.81%** (**3.086*****)

Note: *t*-statistic for the mean abnormal return, Wilcoxon signed-rank test *Z*-statistic for the median abnormal return, and binomial sign test *Z*-statistic for the percent negative abnormal return are reported in parentheses.
$^{*}p<.10$, $^{**}p<.05$, $^{***}p<.01$.

the difference between the actual return of stock i on day t and the estimated normal return of stock i on day t, which is expressed as:

$$AR_{it} = R_{it} - \alpha_i - \beta_i \times R_{mt} \tag{3}$$

The standardized abnormal return (SAR) is calculated as:

$$SAR_{it} = AR_{it}/SD_{it} \tag{4}$$

where $SD_{it} = \{S_i^2 \times [1 + (1/T) + (R_{mt} - R_m)^2 / \sum_{t=1}^{T} (R_{mt} - R_m)^2]\}^{0.5}$, T is the sum of days during estimation period, R_m is the average return of market portfolio during estimation period.
The daily average abnormal return for all the sample companies on day t is:

$$AAR_t = \sum_{i=1}^{N} AR_{it}/N \tag{5}$$

where N is the number of sample companies on day t.
We used a t-test to test the statistical significance of the average abnormal return:

$$t = \sum_{i=1}^{N} \frac{AR_{it}/SD_{it}}{\sqrt{N}} \tag{6}$$

Step 4: Compute the cumulative abnormal return (*CAR*) of stock *i* in the event period [t_1,t_2].
The abnormal returns are then cumulated over the number of event days to get a measure of the cumulative abnormal return for each company.

$$CAR_t(t_1,t_2) = \sum_{t=t_1}^{t_2} AR_{it} \tag{7}$$

Step 5: Compute the average cumulative abnormal return (*ACAR*) of the sample firms in the event period [t_1,t_2].

$$ACAR_t(t_1,t_2) = \frac{1}{N} \sum_{i=1}^{N} CAR_i(t_1,t_2) \tag{8}$$

We used a t-test to test the statistical significance of the average cumulative abnormal return:

$$t = \sum_{i=1}^{N} \frac{\sum_{t=t_1}^{t=t_2} CAR_{it} / \sqrt{\sum_{t=t_1}^{t=t_2} SD_{it}^2}}{\sqrt{N}} \tag{9}$$

4. Results and discussions

4.1. Financial implications of a product recall

Table 3 contains the event study results. It reveals that, on the announcement day (Day 0), there was a mean abnormal return of −0.31%, which was not statistically different from 0. There were also no statistically significant results for the median abnormal return and percentage of negative abnormal returns on Day 0. However, a significant impact was found on the day following the announcement day (Day 1).

The mean abnormal return on Day 1 was −2.21%, the median abnormal return was −1.52% and the percentage of negative abnormal return was 78.57%. All of the statistics in parentheses indicate that the probability of obtaining a negative abnormal return by chance on Day 1 is less than 1%. On the days before the announcement day (Day −5 to Day −1), the abnormal returns varied without statistical significance, driven by chance rather than economic factors (Wright et al., 1995). This suggests that the negative abnormal returns on Day 1 should be attributed to the recall announcement, which was unanticipated by the stock market, and that the product recall announcements were associated with a negative stock price change. This indicates that investors perceive a product recall announcement as a signal of product hazard and impending financial losses for the firm. The cumulative abnormal returns provide further confirmation to this finding. Thus, H_1 was supported.

4.2. Comparison with product recall studies in the United States

Table 4 summarizes the existing event study literature on the stock market reaction to a product recall announcement in the United States market. Comparing Tables 3 and 4, we can see that recall announcements in China are related to greater financial losses in stock price, compared with recall announcements in the United States. The average abnormal return is less than −1% in most U.S. studies, while the mean abnormal return in Chinese markets was −2.21%.

This research provides the opportunity to study recall systems that are in their infancy. The first recall system established in China was in 2004 in the automobile industry, and recall systems for automobiles have developed to the point that there is now an official website to release real-time automobile recall announcements. However, recall systems in the food, drug, toy and electronics products industries were not developed until 2007, and there are no official websites that release real-time recall announcements for these products to the public, as there are in the United States.

In contrast, in the United States, five federal agencies are responsible for product recalls: the Consumer Product Safety Commission (CPSC), the Food and Drug Administration (FDA), the Food Safety and Inspection Service (FSIS), the National Highway Traffic Safety Administration (NHTSA) and the Economic Protection Agency (EPA). The first product recall occurred in 1966, thus, U.S. recall systems are much more mature than Chinese recall systems. U.S. consumers are constantly exposed to recall announcements, many of them for very minor hazards, while a

Table 4
Event study results in the prior literature on US product recall announcements.

Author	Analysis period	Sample size	Industry	Abnormal return on day -1	Abnormal return on day 0
Jarrell and Peltzman (1985)	1967–1981	116	Automobile	−0.81%*** (−1,1)	–
Pruitt and Peterson (1986)	1968–1983	156	Non-automobile	−0.4%***	−0.363%***
Hoffer, et al. (1987)	1970–1984	46	Automobile	−0.565%***	−0.093%
Bromiley and Marcus (1989)	1967–1983	119	Automobile	−0.32%*	−0.32%*
Davidson and Worrell (1992)	1968–1987	133	Non-automobile	−0.36%***	−0.12%
Thomsen and McKenzie (2001)	1992–1998	252 (class 1) 189 (class 2)	Meat and poultry	–	−0.4%**(class 1) 0.2% (class 2)
Chu et al. (2005)	1984–2003	269	Non-automobile	−1.1% ***	−0.6%*
Chen et al. (2009)	1996–2007	24 (proactive) 65 (passive)	Consumer products	–	−0.6%** (proactive) 0.38% (passive)

Note: most previous studies of product recalls in the US found that there were significant negative abnormal returns on Day -1, and some found significant negative abnormal returns on Day 0. In the case of China, however, we only found significant negative abnormal returns on Day 1, not on Day 0. The reason for this may be that previous studies set Day 0 to be the *Wall Street Journal* (*WSJ*) product recall announcement date. However, recall announcements are released to public by official websites on the day prior to their publication in *WSJ*, that is, Day -1. Therefore, investors would be expected to react on event Day -1 or on Day 0, in cases where the announcements are released near, or after the stock market close on Day -1.
*$p<.10$, **$p<.05$, ***$p<.01$.

recall announcement is still perceived as an unusual event in China. Thus, recalls in the U.S. may not have as a negative impact on stock price as product recalls in China do.

During 2007 and 2008, it seemed there were new stories about defective products and recalls almost every day in the United States, mostly leading back to Chinese facilities (Lyles et al., 2008). However, the situation was very different in China, with very little news about product recalls. For example, on March 12, 2009, the U.S. Department of Agriculture's FSIS released a CLASS II recall announcement for chicken drink products manufactured by Khong Guan Corporation for products that did not meet poultry products inspection or poultry exemption requirements, even though no illnesses had been reported (http://www.fsis.usda.gov/News_&_Events/Recall_009_2009_Release/index.asp). However, the products of Khong Guan Corporation were not taken off the shelves in China because the problem was perceived as minor. Hence, when there is a product recall announcement released in China, people assume that there must be a severe product hazard and that there will be great financial losses to the company.

4.3. Signaling effect of recall strategy

Similar to Chen et al. (2009) study, we defined a proactive recall as a recall initiated by a firm which found the potential defect itself and initiated a product recall action before any complaints or incidents were reported by consumers or orders from a related government agency. Otherwise, we defined the recall strategy as passive.

When we traced back through the prior product recall announcements in China, we found that most recalls in the automobile industry followed a proactive recall strategy, while all of the recalls in the other industries followed a passive strategy. This is probably due to a combination of mimetic isomorphism of foreign automakers that are perceived as successful and coercive isomorphism, due to tight government scrutiny of the automotive industry. Thus, H_3 was supported.

Tables 5 and Fig. 2 show that the results for the stock market reaction to different recall strategies. We compared the standardized abnormal returns of different recall strategies on Day 1 by conducting an independent-samples *t*-test, which revealed that the negative standardized abnormal returns for a proactive recall strategy were less than those for a passive recall strategy ($p<0.1$). Thus, the stock market reacted more negatively to passive recall strategy, compared to a proactive recall strategy, supporting H_2.

This result is the opposite of Chen et al.' (2009) finding that a proactive strategy had a more negative effect on firm's financial value than a passive strategy, based on a sample of U.S. product recall announcements. They proposed that a proactive recall strategy would receive greater attention from investors, which the stock market will interpret as a signal of a severe product hazard and impending financial damage to the firm. However, in the Chinese context, investors perceive companies following a proactive recall strategy as more socially responsible and with better internal quality assurance systems. Moreover, consumers and the market may interpret a passive recall strategy as signaling a serious, pervasive and costly defect, hence the involved firms would only recall products when required to, such as the firms involved with the melamine-tainted milk products and lean meat powder tainted pork products shown in Table 1. A proactive recall strategy, on the other hand, may be viewed as a signal of a minor, non-pervasive defect with only minor potential damage to the seller's future revenue streams, such as the recall cases in the automobile industry shown in Table 1.

Table 5
Mean standardized abnormal returns (SAR) on day 1 by recall strategy.

Recall strategy	Mean SAR on Day 1
Proactive ($N=19$)	−0.446*
Passive ($N=23$)	−1.100***

*$p<.10$, **$p<.05$, ***$p<.01$.

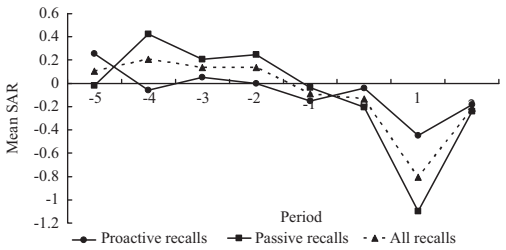

Fig. 2. Mean standardized abnormal return (SAR) by recall strategy.

4.4. Effect of industry

Table 6 lists the mean standardized abnormal returns (SAR) on Day 1 for different industries. We compared the standardized abnormal returns on Day 1 for the food and automobile industries by conducting an independent-samples *t*-test. The negative standardized abnormal returns for automobile industry recalls were less than those for food industry recall announcements ($p<0.05$). This indicates that the food industry suffered a more severe stock market effect of a product recall announcement, while the

Table 6
Mean standardized abnormal returns (SAR) on day 1 by industry.

Industry	Mean of SAR on Day 1
Automobile ($n=20$)	−0.515**
Drugs ($n=11$)	−0.622**
Electronics ($n=5$)	−1.083**
Food ($n=6$)	−1.871***

*$p<.10$, **$p<.05$, ***$p<.01$.

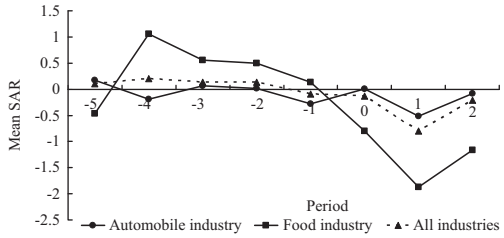

Fig. 3. Mean Standardized Abnormal Returns (SAR) by industry.

automobile industry suffered less, supporting H_4. In Fig. 3, we can clearly see the differing impact of product recalls in the food and automobile industries. Following Day 0, the abnormal returns for the food industry dropped more sharply than they did for the automotive industry. Furthermore, while the abnormal returns recovered quickly for the automotive industry, they continued to decline, in the short run, for the food industry.

5. Conclusions

This study investigates the stock market reaction to product recall announcements in China, providing the opportunity to study recall systems that are in their infancy. Based on a sample of product recall announcements made during the period from 2002 to the March of 2011, we found significant negative abnormal returns on the day following a product recall announcement. This indicates that the Chinese stock market reacts quickly and efficiently to recall announcements. This finding is congruent with findings about product recall announcements in the United States. Our findings further reveal, however, that the negative abnormal return in the China market is generally larger than that in the United States market. Differences in recall systems and recall actions between the United States and China provide a possible explanation for the results.

Our results also reveal that companies in the food industry experience a more severe reaction to a product recall announcement and that food product recalls in China only take place when there have been consumer illnesses. Thus, companies in the food industry are more likely to employ a passive recall strategy. In contrast, Chinese companies in the automobile industry experienced a lower stock price reaction to a product recall announcement. Automobiles are more frequently recalled, even when there have been no accidents, which means that companies in the automobile industry are more likely to follow a proactive recall strategy. Possible explanations for this include differences between the industries in recall system maturity, relationship with foreign manufacturers and structural differences between the industries. In addition, we found that the stock market reacts more negatively to a passive recall strategy than to a proactive strategy. This should encourage companies to follow a proactive product recall strategy and establish systems for mitigating the negative effects of product-harm crises.

A limitation of our study is its relatively small sample size of 42 recall announcements, which is necessary because product recalls are such a recent and unusual phenomenon in China. The sample size is further limited because many product recalls occurred in non-publicly listed companies in China, so market data is not available. Thus, our sample represents the entire population of product recall announcements by publicly listed companies during this time period. In addition, there is somewhat of a precedent for small sample sizes in the product recall literature, which is typically due to the small population of companies of interest. For example, 28 pharmaceutical recall cases were used by Dowdell et al. (1992) study. Govindaraj et al. (2004) studied the case of Firestone Tires and the Ford Explorer product recalls, along with two of Firestone's competitors and two of Ford's competitors, to examine the stock market reaction to announcements by product recall companies and their competitors. Ten cases in U.K. were used by Cheah et al.'s (2007) study of the effect of product recall announcements in the pharmaceuticals industry.

There are a number of interesting directions for future research that build upon the findings of this study. First, while this study addresses product recalls from the shareholders' perspective, it may also be fruitful to examine this issue from the consumers' perspective. Without available secondary data, however, different methodologies such as experiments and surveys may be necessary to investigate this. Second, some in-depth matched case studies for the same industries in China and the United States could be conducted, to assess the reactions by consumers, the government, and the stock market during a product harm crisis, exploring the underpinnings of differences between China and the United States. Finally, research which works to develop an effective supply chain quality management system, in order to prevent the recurrence of product recalls, is becoming increasingly imperative.

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