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Essays on Product Recall Strategies and Effectiveness in the FDA-Regulated Food Sector

Tracy Johnson-hall
Clemson University, tdjohns@clemson.edu

ESSAYS ON PRODUCT RECALL STRATEGIES AND EFFECTIVENESS IN THE FDA-REGULATED FOOD SECTOR

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Tracy Diane Johnson-Hall
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Dr. Aleda M. Roth, Committee Chair
Dr. Manpreet Hora
Dr. Gulru F. Ozkan
Dr. Paul W. Wilson

ABSTRACT

This dissertation consists of two complementary essays that investigate current product recall strategies in the Food and Drug Administration (FDA) regulated food sector. These studies address operations and supply chain factors that influence recall effectiveness with two theoretically-based, empirical approaches. The first essay examines recall effectiveness as measured by time to recall, a proxy for potential consumer exposure to hazardous products (Hora, Bapuji & Roth, 2011) using duration analysis techniques. The unit of analysis is a recall event as documented by the product recall press release. Essay 1 addresses the following question: *how do supply chain competencies related to integration and monitoring systems between supply chain partners, in addition to supply chain complexity factors, relate to time to recall?*

The second essay investigates individual consumer perceptions of operational and supply chain information in the context of a product recall announcement. Consumer perceptions of product recalls are important indicators of recall effectiveness since they are linked, theoretically and empirically, with future consumer behavior; and therefore can affect future market share (Siomkos & Kurzbard, 1994). The unit of analysis is the consumer and a behavioral experiment is implemented to capture the effects of salient factors on consumer perceptions. Essay 2 examines the following question: *how does information provided regarding operational and supply chain management aspects of product failure affect consumer perceptions and repurchase intent when a product is recalled?*

The first essay, *"An Econometric Analysis of Product Recall Strategies and Time to Recall in the Food Industry,"* subjects firms' proactive versus reactive product recall strategies to rigorous empirical scrutiny. In addition, we operationalize supply chain recall detection competence (SCRDC), which reflects the combined operational monitoring, integration and coordination systems across supply chain business partners. We use detection entity as a proxy for SCRDC, with the notion that superior SCRDC will be reflected, in part, by recall defects that are detected internally (i.e., by a supplier or the firm conducting the recall) rather than externally (i.e., by a consumer or a regulatory agency). We integrate multiple secondary data sources and apply duration analysis methods to test our model. Time to recall is an important aspect of recall effectiveness, since perishable products have a finite shelf life; consequently, there is a small window of opportunity in which a recall can be conducted in a way that actually reduces consumer exposure. We find that internal detections (i.e., defects detected by a supplier, or the recalling firm, rather than a consumer or a regulatory agency) have a shorter time to recall than external detections. In addition, our proxy for a firm's quality process maturity (i.e., the number of days of production affected by a particular defect) has a direct effect on time to recall (i.e., longer affected production periods are related to a longer time to recall). These findings have significant implications for future research, practice and policy, in part, because they suggest what types of supply chain strategies and governmental regulations might be implemented to reduce time to recall. Essay 1 contributes to operations and supply chain management theory and product recall research by extending quality management theory (Crosby, 1979; Juran, 1992; Roth,

Giffi, Seal, 1992) via the notion of SCRDC, integrating notions of supply chain complexity (Bozarth, Warsing, Flynn & Flynn, 2009), and illustrating key differences between the applicability of proactive or reactive recall strategies to food products as compared to durable products (e.g., toys, medical devices, automobiles and other consumer products).

The second essay, *"Consumer Perceptions of Product Recall Strategies: The Effect of Attribution on Repurchase Intent, Recall Satisfaction, and Recall Responsibility,"* uses a vignette-based experiment to examine the effects of firm communication to the public regarding the causes of quality failures on consumer perceptions of recall responsibility, recall satisfaction, and repurchase intent. We conduct an exploratory study that manipulates these three dimensions based on attribution theory (i.e., locus, controllability, corrective action) as experimental factors. We find that external locus failures (i.e., defects that happened within a supplier's operations) are related to higher levels of recall satisfaction and a shifting of responsibility away from the recalling firm and towards the supplier. Uncontrollable failures (i.e., failures outside of the volitional control of the recalling firm or supplier) appear to be better tolerated by consumers than controllable failures, as evidenced by effects on repurchase intent, recall satisfaction, and recall responsibility. Finally, providing information about a corrective action intended to address the underlying problem which caused the recall is linked to higher levels of recall satisfaction. Essay 2 contributes to supply chain management theory by adapting attribution theory to the context of operational and supply chain quality failures. In addition to providing preliminary implications for product recall research, this theoretical

adaptation may be more broadly applicable to other situations where firms need to communicate to consumers regarding supply chain and operational events, including supply chain disruptions and corporate social responsibility issues.

In summary, understanding the effectiveness of recall systems in removing potentially harmful products from the hands of consumers, as well as understanding the consumer perceptions of those systems, is not only important for the creation and maintenance of sustainable supply chain performance, it is important for public health and well-being. In addition, this research suggests potential avenues for policy intervention which could provide additional incentives for firms to improve their quality processes. Future research can determine how these findings may (or may not) be generalizable to other industries and product types.

DEDICATION

To Amanda, Audrey, Ben, Benjamin, Brent, Dillon, Emma, Isaac, Kate, Kelsey, Kyle, Matthew, Ryan, Sarah, Suzanne and curious minds everywhere: "though this be madness, yet there is method in't," Hamlet Act 2, Scene 2.

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My mother and grandmother have had a tremendous influence on my character and my choice of career through the standards and expectations they have always set for me, and through the extraordinary value they have placed on education. Although they themselves had few formal educational opportunities, they taught me that education was essential to both economic and intellectual freedom. This is an enduring gift and I cannot adequately express my thanks.

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CHAPTER 1

INTRODUCTION

1.1 Practical and Theoretical Background

This dissertation examines product recalls in two related essays which approach the issue from different theoretical and methodological perspectives. Product recalls are an observable manifestation of quality failures which result in product harm events (i.e., unsafe products reach consumers) (Siomkos & Kurzbard, 1994). More specifically, recalls are the result of *external quality failures* (i.e., quality failures that exist outside the boundaries of the firms that are primarily responsible for the quality of finished goods) (Juran, 1969; 1972; 1992). Estimated societal impacts of product harm – whether from faulty consumer products, foodborne illnesses, or defective automobile components - are substantial (e.g., total costs of unsafe consumer products, including healthcare costs and property damage are estimated at $900 billion annually; Consumer Product Safety Commission, 2012). Furthermore, the effects on businesses can be severe – in terms of the initial impact to the firm conducting the recall, consequences for the supply chain, as well as the industry-wide spillover effects.

While recalls of many product types have been on the rise over the past decade, rigorous empirical research which characterizes the strategic and operational nature of these failures and factors that influence the relative speed of current industry and regulatory systems to handle the recalls, is extremely limited (Hora et al., 2011; Roth, Tsay, Pullman, & Gray, 2008ab). Furthermore, the extant empirical literature that deals with both operational and supply chain aspects of food recalls is nearly nonexistent,

despite the significant burden which it imposes on firms as well as public health. For example, foodborne illness affects 1 in 6 residents of the United States (US), and is estimated to create total societal costs, including healthcare costs and productivity losses in excess of $1.4 trillion annually (Roberts, 2007).

This dissertation examines product recalls in the context of the Food and Drug Administration (FDA) regulated food sector. We theoretically and empirically address the following questions: 1) *how do supply chain competencies related to integration and monitoring systems between supply chain partners, in addition to supply chain complexity factors, relate to time to recall?* and, 2) *how does information provided regarding operational and supply chain management aspects of product failure affect consumer perceptions and repurchase intent when a product is recalled?*

Taken as a whole, the body of literature on product recalls varies extensively with respect to methods and results. Studies have been conducted on demand and shareholder value impacts via event history studies (Chen, Ganesan & Liu, 2009; Chu, Lin & Prather, 2005; Haunschild & Rhee, 2004; Rhee & Haunschild, 2006; Thirumalai & Sinha, 2011) and recall communications and consumer perceptions of firm management of product recalls via experiments (Dawar & Pillutla, 2000; Klein & Dawar, 2004, Laufer, Gillespie, McBride & Gonzalez, 2005; Laufer & Jung, 2010).

While the recent empirical evidence seems to indicate that publically traded firms, in particular, may have significant incentives to delay recalls in order to minimize impacts to shareholder value (Chen et al., 2009), the marketing, communications and crisis management literature suggests the opposite; namely, that firms that respond earlier and

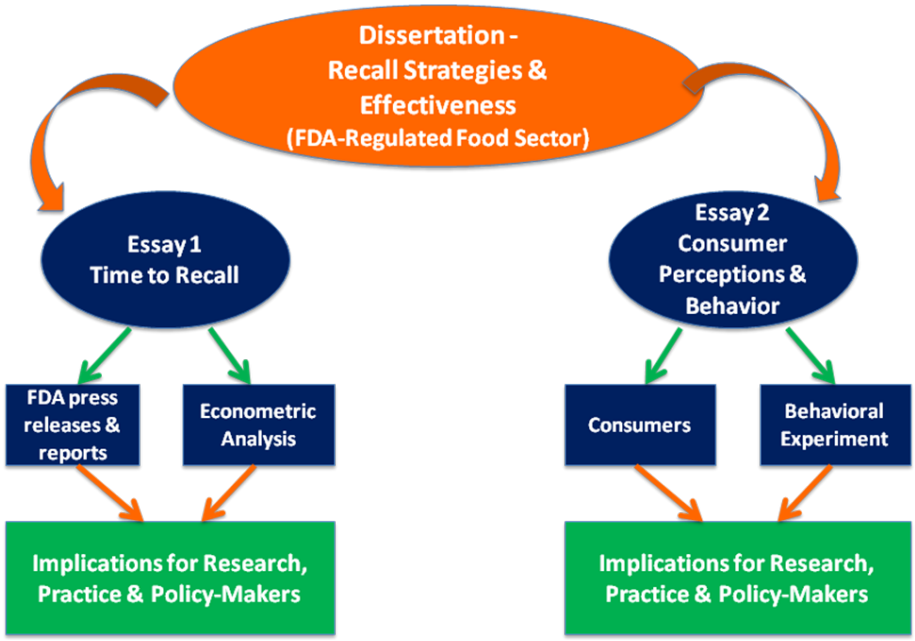
take responsibility for product failures, if appropriate, can limit reputational and market share effects (Dawar & Pillutla, 2000; Laufer & Coombs, 2006; Pearson & Clair, 1998; Smith, Thomas, and Quelch, 1998). This creates a paradox for firms developing and implementing recall strategies in terms of 1) recall timing and 2) recall communication content. In other words, with respect to recall timing, conventional wisdom would suggest that it is more advantageous to announce recalls as soon as possible, yet in practice, firms may delay the recall announcement. With regard to recall communication, again, conventional wisdom suggests that it would be preferable to directly and candidly communicate the circumstances of the product failure; however in practice firms may only communicate such information as is required by law. This dissertation addresses these dilemmas by examining recall timing and recall communication in the operations and supply chain management context with two different theoretical and empirical approaches.

Essay 1 offers implications with regard to the issue of recall timing by exploring recall strategy and operational and supply chain characteristics that influence recall timing in the FDA-regulated food sector using a duration analysis of secondary data[1]. Essay 2 takes a different perspective, investigating FDA-regulated food recalls from the perspective of the consumer and addressing the latter half of the recall strategy paradox by manipulating information provided in a framed field experiment and measuring the resulting differences in consumer perceptions. Figure 1.1 illustrates these two different

[1] The FDA regulates 80% of food consumed in the US including fruits, grains, vegetables, in-shell eggs, infant formula, and a variety of processed and mixture items. The United States Department of Agriculture (USDA) regulates the remaining 20% of food products which consist of egg products, meat, and poultry. FDA-regulated foods represent an estimated 75% of food expenditures in the US (Institute of Medicine and National Research Council of the National Academies, 2010)

approaches and how we expect to contribute to academia, managerial practice, and governmental policy.

Figure 1.1 Dissertation Overview



1.2 Product Recall and Quality Literature

This dissertation builds upon the literature examining product recall speed in the toy industry (Hora et al., 2011), and event history studies of shareholder value impacts due to product recalls in the marketing (Chen et al., 2009), organizational (Haunschild & Rhee, 2004; Rhee & Haunschild, 2006), economics (Chu et al., 2005; Crafton, Hoffer & Reilly, 1981; Hoffer, Pruitt & Reilly, 1988; Reilly & Hoffer, 1983) and operations management literature (Thirumalai & Sinha, 2011). In addition this work is grounded in the crisis communications and product harm literature (Dawar & Pillutla, 2000; Laufer & Coombs,

2006; Pearson & Clair, 1998; Siomkos & Kurzbard, 1994). More specific to operations and supply chain management literature, this dissertation broadens our understanding of recent work on quality risk issues in global food supply chains (Lyles, Flynn, & Froehlich, 2008; Roth et al., 2008ab) and in the pharmaceutical industry (Gray, Roth & Tomlin, 2009a; Gray, Tomlin & Roth, 2009b; Gray, Roth & Tomlin, 2011). In addition to we integrate traditional quality management theory (Crosby, 1979; Juran, 1992; Roth et al., 1992) into the recall strategy literature (Chen et al., 2009; Hora et al., 2011). The prior related research highlights the critical importance of understanding firm strategies around recalls as an emerging, new global quality problem (Lyles et al., 2008; Roth et al., 2008ab).

While the body of literature dealing with product recalls draws upon multiple reference disciplines (e.g. marketing, economics, and strategy, and psychology), there are two dominant approaches to this topic: 1) event history studies, which examine shareholder value or demand impacts due to product recalls (Chu et al., 2005; Crafton et al., 1981; Hoffer et al., 1988; Reilly & Hoffer, 1983; Thomsen & McKenzie, 2001) and 2) experiments, which study the different aspects of consumer behavior related to product harm events. Some of this experimental work specifically addresses product recalls (Dawar & Pillutla, 2000; Laufer & Coombs, 2006; Pearson & Clair, 1998; Siomkos & Kurzbard, 1994). Furthermore, prior studies, with a few exceptions (Roth et al., 2008ab; Salin & Hooker, 2001; Thomsen & McKenzie, 2001; Teratanavat, Salin & Hooker, 2005; Marsh, Schroeder & Mintert, 2004; Thomsen & McKenzie, 2001; Thomsen, Shiptsova, & Hamm, 2006), evaluate product recalls in the context of durable products, rather than

perishable products. Studies that deal with recall timing and associated risks, either empirically or conceptually, are extremely limited (Hora et al., 2011; Lyles et al., 2008; Roth et al., 2008ab; Teratanavat et al., 2005).

In summary, the body of event history studies has yielded empirical results which suggest that 1) shareholder value *may* be negatively impacted by product recalls, contingent on a number of factors (e.g., recall severity and industry and firm characteristics, including size and reputation) and predominantly in the short term (Chu et al., 2005; Hoffer et al., 1988; Jarrell & Peltzman, 1985, Pruitt & Peterson, 1986; Rhee & Haunschild, 2006; Thirumalai & Sinha, 2011); 2) product recalls can have short term impacts on demand, which may spill over to other products manufactured by the same firm (Reilly & Hoffer, 1983; Thomsen et al., 2006); and 3) firms appear to learn from prior recalls, reducing the likelihood of future recall events (Haunschild & Rhee, 2006; Thirumalai & Sinha, 2011). Literature using consumer-based experiments have indicated that attribution theory has predictive validity for the manner in which consumers perceive aspects of product failures, especially when failures may be attributable to the firm or the consumer (Folkes, 1984); and that consumers more favorably evaluate firms conducting recalls as well as the affected products when firm communications are more transparent and when firms take responsibility for failures (Siomkos & Kurzbard, 1994; Klein & Dawar, 2004).

Two other intriguing results from the literature contribute directly to this dissertation research: 1) the finding that publically traded firms may have incentives to delay recalls to minimize shareholder value impacts (Chen et al., 2009); and 2) evidence which

indicates that the indirect costs of product recalls to firms (e.g., shareholder value, market share, brand equity, reputation) exceed the direct costs (e.g., replacement/repair/refund, reverse logistics, product liability) (Jarrell & Peltzman, 1985; Rupp, 2003). These prior related research findings motivate our work, in part, because of their implications for managerial practice and policy.

The issue of incentives to delay recalls highlights the potential for market forces to promote corporate policy which may not provide an adequate level of protection of public health and safety, since delayed recalls result in greater consumer exposure to unsafe products (Chen et al., 2009). Alternatively, if, as some studies find, market penalties to shareholder value are not significant, on average, then market forces may unlikely provide adequate incentives for firms to invest in an appropriate level of quality systems (Hoffer et al., 1988; Thirumulai & Sinha, 2011). Governmental policy, therefore, is a necessary and critical factor in promoting, maintaining and improving the safety of consumer products.

The issue of indirect versus direct costs of recalls highlights one of the challenges facing firms with respect to recall prevention and response. In effect, the losses that are simplest to measure and manage, in some respects, are not the most serious issues facing the firm. Consequently firms may have difficulty in appropriately developing and implementing recall strategies, because the relationship between recall strategies and outcomes is often unclear and delayed, at best. The market share and reputational effects of product recalls are rooted in stakeholder perceptions and, perhaps, to a greater extent, by consumer perceptions and behavior. The contexts in which product harm events and

product recalls have been studied, with respect to consumer perceptions, have varied. They include experiments which manipulate severity of harm, statements regarding corporate social responsibility, brand equity and firm reputation (Dawar & Pillutla, 2000; Folkes, 1984; Klein & Dawar, 2004; Laufer & Coombs, 2006; Laufer, Gillespie, McBride, & Gonzales, 2005; Siomkos & Kurzbard, 1994).

Attribution theory, a theoretical lens adopted from cognitive psychology, has been used to evaluate how consumers perceive product failures, primarily in the context of locus, or the source of the failure (Folkes, 1984; Laufer, 2002; Laufer et al., 2005). These experiments have largely focused on perceptual differences when the source (locus) of product failure is the consumer (e.g., tires fail because of consumer driving habits) versus the firm (e.g., tires fail because of an underlying manufacturing defect). This stream of literature has confirmed, in general, that severity of the recall, in terms of the hazard to the consumer, has negative effects on the consumer perceptions of firms. In some cases, brand associations, corporate social responsibility information and other firm-specific factors can minimize negative impacts on the consumer perceptions of the firm and the recalled product (Klein & Dawar, 2004; Laufer et al., 2005; Siomkos & Kurzbard, 1994). While this literature has established a cumulative tradition of using attribution theory to explain consumer perceptions of negative product experiences, it has, to date, not been applied to how consumers interpret operational information.

1.3 Gaps in the Operations and Supply Chain Management Literature

Research on how firms conduct recalls is sparse in the operations and supply chain management literature. Much less is known about recall strategies in the food industry,

where transparency is relatively low (Roth et al., 2008ab). However, once a potential product defect is detected, the speed of recall responsiveness as well as the content of information available about the failure becomes imperative for all stakeholders. Thus, this dissertation aims to begin filling in the gap for rigorous research that adequately reflects the extant operations and supply chain strategies and the complex interactions of focal firms with their supply chains in the context of food product recalls.

In Essay 1, we examine the nature of product harm issues and product recalls of perishable food products, as compared with durable products (e.g., consumer products, electronics, medical devices and automobiles). We argue that substantive differences in the nature of failures for perishables (e.g. food and pharmaceuticals), in addition to the ubiquitous nature of their consumption, presents a particular challenge to the operating systems – both industrial and governmental – that must deal with these failures. For food, specifically, in addition to the unavoidably high level of consumer exposure, the conformance quality attributes of these products are largely *credence attributes*, which make it exceedingly difficult, or impossible, for consumers to verify prior to purchase (Darby & Karni, 1973; Nelson, 1970; Roth et al., 2008ab). Consequently, both the industrial and regulatory systems that ensure process quality in food products are currently the primary safeguards against product harm due to conformance quality failures. In summary, understanding the effectiveness of these systems in removing potentially harmful products from the hands of consumers is an important operational and societal issue in addition to being necessary for the creation and maintenance of

sustainable supply chain performance (FDA, 2011a; Ollinger & Moore, 2009; Gray, Roth & Leiblein, 2012 and Gray et al., 2011).

Essay 2 is motivated, in part, because understanding consumer perceptions and related behavior subsequent to a recall is an important piece of the recall strategy equation. We investigate the relationship between firm actions and consumer perceptions via a behavioral experiment, providing a high level of internal validity for investigating relationships that are virtually impossible to evaluate during an actual recall event. Essay 2 also contributes to the extant literature by providing insights into "indirect" recall costs. Extant literature supports the notion that indirect recall costs are larger than direct recall costs (Jarrell & Peltzman, 1985; Rupp, 2003). Indirect costs of recalls include market share, shareholder value and reputational impacts to the firm. Direct recall costs include more tangible and easily measured impacts such as reverse logistics, warranty, replacement, and repair costs, as well as product liability (Jarrell & Peltzman, 1985; Rupp, 2003).

We believe it is important to examine the link between operational and supply chain dimensions of recalls and selected indirect costs (as we do in Essay 2), which are predicated on consumer repurchase behavior, in part because indirect costs are difficult to measure and potentially hidden to practitioners. While understanding recalls costs is of obvious relevance to firms seeking to minimize the impacts of product recalls on their operations and profits, it is equally important for policy-makers, because it sheds light on how regulations could be structured to motivate firms to act in a way that is consistent with the objectives of human health and safety.

1.4 DISSERTATION CONTRIBUTIONS

To examine the recall strategies used by FDA-regulated food firms, we apply two different theoretically-based lenses (i.e., the firm and the consumers) and empirical approaches (i.e. secondary data and a behavioral experiment). The first study[2], "*An Econometric Analysis of Product Recall Strategies and Time to Recall in the Food Industry,"* subjects firms' product recall strategies to rigorous empirical scrutiny by examining the effect of proactive and reactive strategies, complexity factors and supply chain recall detection competencies on *time to recall*, a proxy for recall effectiveness (Chapter 2, Essay 1). Secondary data is employed for the analyses. In the second study, "*Consumer Perceptions of Product Recall Strategies: The Effect of Attribution on Recall Responsibility, Recall Satisfaction and Repurchase Intent,"* we apply a vignette-based experiment to examine the effect of recall communication strategies on consumer perceptions, including recall satisfaction, attribution of responsibility for the product recall and repurchase intent (Chapter 3, Essay 2). Together, these two studies make contributions to academia, industry, and policy-makers, by offering several insights. First, Essay 1 suggests how firms may allocate resources to supply chain and process monitoring and improvement activities to reduce the need for recalls in the first place, as well as to improve defect detection capabilities within the supply chain. Essay 1 also examines the operational and supply chain factors that influence time to recall, and benchmark recall speed for various types of products and recalling entities. Essay 2 suggests how recall communications can be managed to minimize negative impacts to the

[2] The proposal for Essay 1 was the recipient of the 2011 Joseph M. Juran Center for Leadership in Quality Doctoral Dissertation Fellows Award (Carlson School of Management University of Minnesota).

recalling firm, contingent upon sufficient supply chain capabilities. Finally, this dissertation's findings are equally relevant to policy, since reducing time to recall can reduce consumer exposure to defective products and because recall announcement content is dictated, in part, by regulation.

Taking the mixed evidence for market incentives (e.g. impacts to shareholder value caused by the product recall) for firms to reduce recalls by avoiding external quality failures (Chu et al., 2005; Thirumalai & Sinha, 2011), together with the potential for publically traded firms to benefit from delaying recalls (Chen et al., 2009), we argue that there is a critical need for research that examines multiple performance aspects of product recalls as well as tradeoffs between different recall strategies. Furthemore, research is needed which provides implications and recommendations not only for the firms that must manage this issue, but also for policy-makers charged with protecting public health and safety.

Together, these two empirical essays add to the existing body of literature regarding product recalls while extending quality management theory (Essay 1), examining recall strategy in a novel context (Essay 1) and adapting attribution theory to the operations and supply chain management context (Essay 2). We summarize our findings in the context of the larger stream of literature and suggest potential future research directions based on this work in Chapter 4 (Conclusions). In summary, these two essays take two different views of recall outcomes (i.e. time to recall and consumer perceptions) and, in doing so, contribute new and relevant insights to understanding and improving recall effectiveness.

CHAPTER 2

AN ECONOMETRIC ANALYSIS OF PRODUCT RECALL STRATEGIES AND TIME TO RECALL IN THE FOOD INDUSTRY

2.1 INTRODUCTION

We investigate supply chain and complexity factors associated with time to product recall in the context of the US food industry, specifically those products regulated by the FDA. The FDA is responsible for the regulation of 80% of all food sold in the US with the remainder being regulated by the United States Department of Agriculture (USDA) (Institute of Medicine and National Research Council of the National Academies, 2010). Over the past decade, public awareness of all product recalls—from cars to toys to batteries to pharmaceuticals to food—has been on the rise. Consequently, policy-makers have responded with concern, some of it specific to US food quality systems (GAO, 2000; 2004ab), and the effectiveness, (specifically the *speed*) of food recalls and incentives for firms to act in the best interests of public health, as evidenced in the following excerpt from a Government Accountability Office study (GAO, 2004a):

> *"USDA and FDA do not know how promptly and completely companies are carrying out recalls. Neither agency's guidance provides time frames for companies on how quickly to initiate and carry out recalls. Consequently, companies may have less impetus to notify downstream customers and remove potentially unsafe food from the marketplace" (GAO, 2004a, p. 4)*[3].

[3] While some FDA policies have changed since this GAO report (2004), the FDA position on recall time frames remains the same: it is expressed in guidance, rather than regulation (guidance is not enforceable). It is stated as follows "Issuance of a press release should be the highest priority and it should be issued **promptly**" (FDA, 2009a, emphasis in the original).

Recalls emanate from quality failures detected after products have been released for distribution and consumption. The extant quality and operations management literature terms such failures as *external* quality failures, because the defects are detected after the product leaves the control of the supply chain entity, where the problem first occurred (Gryna, 1999; Juran, 1992). In turn, one or more entities in the supply chain must participate in the response. Accordingly, given that all recalls are external failures, we propose that it is preferable, in terms of recall effectiveness, for a business-to-business (B2B) supply chain entity to detect the defect before a consumer or regulatory agency does and acts upon this information.

We introduce the term *supply chain recall detection competence* (SCRDC) to connote superior operational monitoring, integration and coordination systems across B2B supply chain partners, including suppliers, manufacturers, and channel partners, which, in part, allow for the earlier detection of external failures. In this sense, while product recalls are the manifestations of external quality failures, the effectiveness of recall processes depend, in part, on the complex relationships between the firm announcing the recall and its supply chain partners. In our study, we use *time to recall* to represent one important dimension of recall effectiveness, positing that SCRDC is an important factor in reducing the amount of time which elapses between the end of production of a specific item to when the recall is first announced to the public.

We note that, for perishable consumables, such as food and pharmaceuticals (which are also not completely testable (Roth et al., 2008ab)), the window of opportunity for mitigating consumer risk is further limited to the shelf life of the defective product. Since

shelf life begins at the end of a batch, or production run, our definition of time to recall captures the risk that a contaminated or inappropriate food product[4] will be consumed *before* the public is made aware of the problem. As such, the consumer-level reverse logistics process typically only begins with the FDA announcement.

From the perspective of the firm conducting the recall (henceforth, referred to as the *recalling firm*), arguably, reducing the time to recall poses tradeoffs in incentives (Chen et al., 2009; Hora et al., 2011). On the one hand, the sooner the public announcement is made, the more potential consumer exposure is reduced, therefore limiting firm liability; furthermore, lost sales may be minimized by early and responsive communication (Dawar & Pillutla, 2000; Siomkos & Kurzbard, 1994). On the other hand, longer time to recall may reduce the number of units subject to reverse logistics processes, because the product has expired. Furthermore, given the great difficulty in attributing illness to a specific defective food, longer time to recall may actually benefit the recalling firm if the timing of the recall further confuses the attribution of actual illnesses to the recalled product (Mead, Slutsker, Dietz, McCaig, Bresse, Shapiro Griffin & Taux, 1999). It is less clear how recall timing will affect brand equity and shareholder value in this sector (Chen et al., 2009; Chu et al., 2005; Teratanavat et al, 2005; Thirumalai & Sinha, 2011; Thomsen & McKenzie, 2001).

Prior empirical research is almost exclusively confined to examining the product recalls of durable products and largely examines demand or shareholder value impacts

[4] Contaminated food products are those with pathogens known to be harmful or otherwise adulterated (e.g., greater than allowable levels of toxins or heavy metals), whereas inappropriate products refers to products not fit to be consumed by a group of people, but the consumer does not have enough information to make this determination (i.e., either the information is not available or it is mislabeled; for example, snack foods with undeclared allergens, such undeclared peanuts or shellfish on the label).

via event history studies (Chen et al., 2009; Chu et al., 2005; Jarrell & Peltzman, 1985; Rhee & Haunschild, 2006; Rupp, 2003). Only a handful of studies investigate factors influencing the relative speed of the current industry and regulatory systems to handle recalls (Hora et al., 2011; Roth et al., 2008ab; Lyles et al., 2008). With the notable exception of Marsh, Schroeder & Mintert (2004), Thomsen & McKenzie (2001), and Thomsen et al. (2006), perishable products, and specifically food product recalls, have not been subjected to rigorous empirical scrutiny. Moreover, despite the importance of food safety to public well-being and the need to understand how to improve supply chain systems to increase recall effectiveness, these studies neither address time to recall nor incorporate operations and supply chain management issues. Consequently, we begin to fill this void by theoretically and empirically addressing the following question: *how does the SCRDC, in addition to complexity factors relate to time to recall in the FDA regulated food sector?*

We offer the following contrasting examples of actual food product recalls to contextualize our research:

> ***Example 1:*** On June 17, 2008, a concentrated beverage was recalled from a facility in Montana due to potential contamination with *Clostridium botulinum*, a pathogen that can cause serious illness or death. At the time of the recall, the product was already in distribution at retailers and being used in coffee shops in Montana and Arizona. The expiration dates of the products affected by the recall were given as September 23, 2009 through May 22, 2010. At the time of the recall, no illnesses had been reported as a result of consuming this product. The defect, which was due to a processing issue which rendered the product

vulnerable to contamination, was discovered through an internal records audit of processing records (See Appendix 2A for the complete press release).

Example 2: On October 20, 2010, all packaged fresh produce (e.g., prepackaged chopped celery) processed between January 1, 2010 and October 19, 2010 was recalled from a manufacturing facility in Texas. At the time of the recall, the product was in use in restaurants and institutional kitchens in Texas. The recall was initiated based on a state health department investigation of an outbreak of *Listeria monocytogenes*, which was linked to ten illnesses, including five deaths, which occurred over an eight month period. After the state agency's investigation implicated products from this particular facility, an inspection conducted by the state agency confirmed contamination with *Listeria* which matched the outbreak (See Appendix 2A for the complete press release).

These two examples underscore several important elements of US food product recalls: 1) whether or not illnesses were associated with the defective product at the time of the recall; and 2) which organization detected the defect (in this case, an internal audit versus an agency investigation of an outbreak of the illness) and 3) recall timing (clearly, the concentrated beverage product had a substantial amount of remaining shelf life at the time of the recall, increasing the chances that all the recalled product had not yet been consumed, while the fresh produce recall affected months' worth of production, which had already expired). Our study explores aspects of all of these elements to rigorously investigate factors that affect recall timing. As we develop our conceptual framework, we will return to these examples, to illustrate factors included in our research.

The cornerstone of the US food safety initiatives and regulations is to keep the nation's food safe from both unintended and deliberate contamination. Unfortunately,

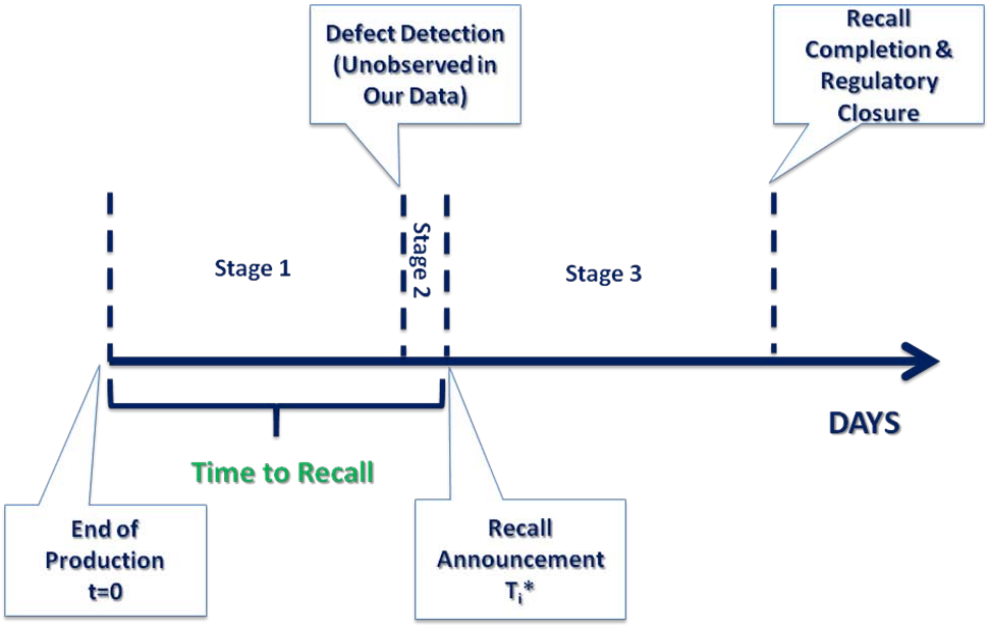
contaminated food products continue to reach distribution channels and, ultimately, consumers. For example, in the first quarter of the year 2012 alone, there were 142 food recalls, initiated by more than 130 companies (with 9 of these companies having multiple recalls) (FDA, 2012). With nearly 7 million units affected and 46 consumer illnesses attributed[5] to these recalls nationwide, managing these events poses substantial challenges to supply chain systems. Such challenges – involving issues of defect detection, tracing affected units and reverse logistics – suggest that the concept of *recall effectiveness* has multiple dimensions. In addition to the public health considerations of preventing or minimizing illnesses and issues related to managing firm liability and impacts to brand equity, reputation and sales, we propose that recall effectiveness could be evaluated in a number of different ways, including the speed of defect detection, timeliness of recall announcements (particularly relative to product shelf life for perishable products), and the volume of the product recovered. Our study focuses on the timing aspects of food product recalls.

Total recall time can be decomposed into three stages: 1) Stage 1: end of production to time of defect detection, 2) Stage 2: time of defect detection to public notification, and 3) Stage 3: public notification to the closure of recall activities, including reverse logistic processes, by the recalling firm and recall monitoring by the regulatory agency. In this research, we use the term *time to recall* to reflect the combined effectiveness of first two stages of the total recall process; speeding up the time from the end of production to the

[5] Clearly, there may be much larger numbers of consumers with undiagnosed or undetected health consequences related to the contaminated products; the underreporting of foodborne illness associated with pathogens, for example, is well-established (Mead et al., 1999).

public announcement results in less consumer exposure to potentially harmful products (Hora et al., 2011). Furthermore, the exact timing of Stage 1 is unobserved in our sample. We operationalize *time to recall* as the number of days between the end of production and the date of the first FDA recall announcement for a particular product. Figure 2.1 illustrates the three stages of total recall time and the focus of our study, time to recall.

Figure 2.1 Total Recall Time (Unit of Analysis = Recall Announcement)



The quality of food products and the timing of food product recall announcements have profound implications for supply chain and operations management research and practice, impacting consumer safety and public health, in part, due to the nature and ubiquity of product consumption. Foodborne pathogenic illnesses impose an estimated $77.7 billion dollars of healthcare costs (Scharff, 2012), up to $1.4 trillion in terms of total societal cost annually (Roberts, 2007). However, due to the challenges of linking

foodborne illnesses to specific products, as well as the underreporting of these illnesses, recalled food products only represent a fraction of the conformance quality failures that actually reach US consumers (Mead et al., 1999).

Based on Center for Disease Control (CDC) research, foodborne illnesses are underreported by an estimated factor of 20 to 38, depending on the organism; accounting for underreporting, an estimated 48 million persons are made ill annually in the US by foodborne illness; 9.4 million of these illnesses are attributed to "known" pathogens (Scallen, Hoekstra, Angulo, Tauxe, Widdowson, Roy, Jones & Griffin, 2011). This occurs, in large part, because persons suffering from mild cases of foodborne illness do not seek medical treatment, as well as limited laboratory diagnoses for mild cases (Mead et al., 1999). Based on the limited testability of food products, which complicates defect detection, as well as the difficulty in tracing back the source of the outbreaks (even when outbreaks are detected by authorities), as well as the gross underreporting of foodborne illness to regulatory agencies, we infer that the total number of food products in distribution which violate federal standards for pathogens or other contaminants greatly exceeds the number of products recalled.[6]

While the consumption of food is, of course, unavoidable, there is evidence that food safety issues are difficult to avoid: the CDC estimates that 1 in 6 US residents contracts a foodborne illness annually due to a pathogen (Scallen et al., 2011)[7]. Furthermore, food

[6] The most recent CDC data indicates that 1,034 outbreaks were investigated in 2008, with 579 of these outbreaks (56%) failing to be traced back to a specific food product source.

[7] Not all foodborne illnesses are attributable to production defects: food preparation in commercial, institutional and homes are responsible for a portion foodborne illnesses, however difficulty in monitoring the source of foodborne illness make estimating the proportion of illnesses attributable to production versus other settings extremely difficult (FDA, 2010).

quality failures have profound spillover effects on businesses, including farms, restaurants, retailers and distributors (for examples of firm failures that may be attributable to food recalls, see Yousuf (2010) for reports of Topps Meats, the Peanut Corporation of America, and AP Military which ceased operations and filed for bankruptcy subsequent to recalls of ground beef, peanut products and spinach, respectively).

Underscoring the importance of studying recalls in this context, it is anticipated that trends towards increasing numbers of food product recalls are unlikely to reverse in the near future. This expectation is based on several factors, including trends in the food industry to increasingly source products from countries with low manufacturing costs, poorly established quality systems and less regulatory enforcement, the relatively low level of inspection and testing activities that US agencies are currently able to offer for both foreign and domestic products and ingredients, and the highly concentrated nature of food commodity manufacturing, which lends itself to high volume, broad recalls affecting many different firms and products (FDA, 2011a; Gray et al., 2009ab; Roth et al., 2008ab).

Prior characterizations of recall strategies as *proactive,* or *reactive,* have focused on the timing of recall announcements with respect to whether injuries or illnesses have occurred prior to the announcement (Chen et al., 2009; Hora et al., 2011; Siomkos & Kurzbard, 1994). *Proactive recall strategies* are indicated when no injuries or illnesses have been reported to the regulatory agency prior to the recall. In contrast, *reactive recall*

strategies are indicated when injury or illnesses have been reported to the regulatory agency prior to the recall.

We contend that simply characterizing recall strategies as proactive or reactive is not specific enough for recalls of perishable products for several reasons. Firstly, we observe that product recalls in these sectors, in contrast to durable products, are predominantly proactive – in other words - illnesses have not been attributed to the recalled products at the time of the recall announcement. We suggest that there are several factors which contribute to this important difference. Second, due to the difficulty in attributing foodborne illness to a particular food, we suspect that many food recalls only *appear* to be proactive because illnesses have not been traced back to a specific defective product (Buzby, Frenzen, & Rasco, 2001; Buzby, 2003; Mead et al., 1999). Third, food recalls are almost exclusively the result of conformance quality failures—which, in this context, implies that the quality failure is considered to be regulatory non-compliance, triggering mandatory reporting, which may contribute to recalls occurring before illnesses are attributed to the recalled product (FDA, 2010). Finally, since the nature of the quality issue is non-conformance, multiple failures are typically not necessary to confirm the existence of a quality issue – one confirmed positive test result for a pathogen in a product already in distribution, for example, is enough to trigger reporting to a regulatory agency (89.5% of the defects in our final sample are pathogenic in nature). This can again be contrasted with quality issues in durable products frequently associated with design issues; typically multiple instances of a failure (e.g., accidents or injuries) occur prior to a product harm issue being recognized (Hora et al., 2011).

To illustrate the difference between the types of failure routinely associated with food product recalls, as compared with more durable products, we return to our prior examples. In both of our examples, the defect which caused the recall is a pathogen, the presence of which, in either of these recalled products, is considered inconsistent with the product specifications and violates federal law. If we compare this situation to a defective durable product, such as a toy, we find that while a toy might be recalled due to a conformance quality failure (e.g., the use of paint exceeding federal standards for lead content), it is far more likely for the toy to be recalled due to a design failure (e.g., the use of small, powerful magnets in such a way that they are readily accessible to small children, and consequently, may be ingested and cause injury (Hora et al., 2011)). Similarly, if we examine the types of failures for which other types of durable products are recalled, we find that design issues are far more common than conformance quality issues (Bapuji & Beamish, 2008).

The predominance of design failure issues for durable product recalls shifts detection away from a laboratory test, or a facility audit or inspection, to consumer use and injury, which, when reported to the firm and the agency, eventually results in an investigation, and, if a reasonable potential for harm within the scope of the law is found, requires a product recall. We propose that this difference between the failure modes for perishable versus durable products has important implications for the tendency for recalls to be proactive or reactive.

In the case of durable products with design flaws, the consumer's injury by a product can be a part of the detection process, and therefore, contributes to the propensity for

such recalls to be reactive, rather than proactive. For foods, the difficulty in attributing an illness to a particular defective product compounds this difference, resulting in very few confirmed reactive recalls in that sector.[8]

We propose a theoretical framework that explores an alternative view of recall effectiveness by considering the time to recall between the end of production and the recall announcement (See Figure 2.1, where the unit of analysis is the press release announcing the recall). More specifically, we argue this: the *entity* detecting a defect that results in a product recall affects time to recall, and consequently, time to recall captures one salient aspect of the recalling firm's realized outcome. The *recalling firm* is the firm that makes the recall announcement. The *detection entity* is operationalized in terms of where the quality problem is first detected within the supply chain and reflects SCRDC. We define an *internal detection* entity as being an upstream B2B supply chain entity[9] (i.e., supplier, manufacturer, distributor, or retailer), whereas an *external detection* entity is the consumer or regulatory agency.

Using the dominant logic from quality management, *internally detected* recalls, controlling for other factors, are posited to have a shorter time to recall than those *externally detected*; and hence, the SCRDC will be higher if the detection is internal, rather than external. The logic of our analogy is this: in traditional quality management theory, external failures, as compared with the internal failures, will result in higher

[8] In our final sample of 258 food recalls, 12.4% are reactive, rather than proactive. In Hora et al., 2011, the proportion of reactive recalls in a sample of toy recalls over a 15 year period was as follows: 38% of recalls were reactive and 76% were related to design flaws.

[9] We note that different food products, even from the same company, may have different supply chains; therefore, the relative degree of integration and coordination among B2B partners to monitor and communicate well when a problem occurs is posited to be as important as any individual firm in the chain.

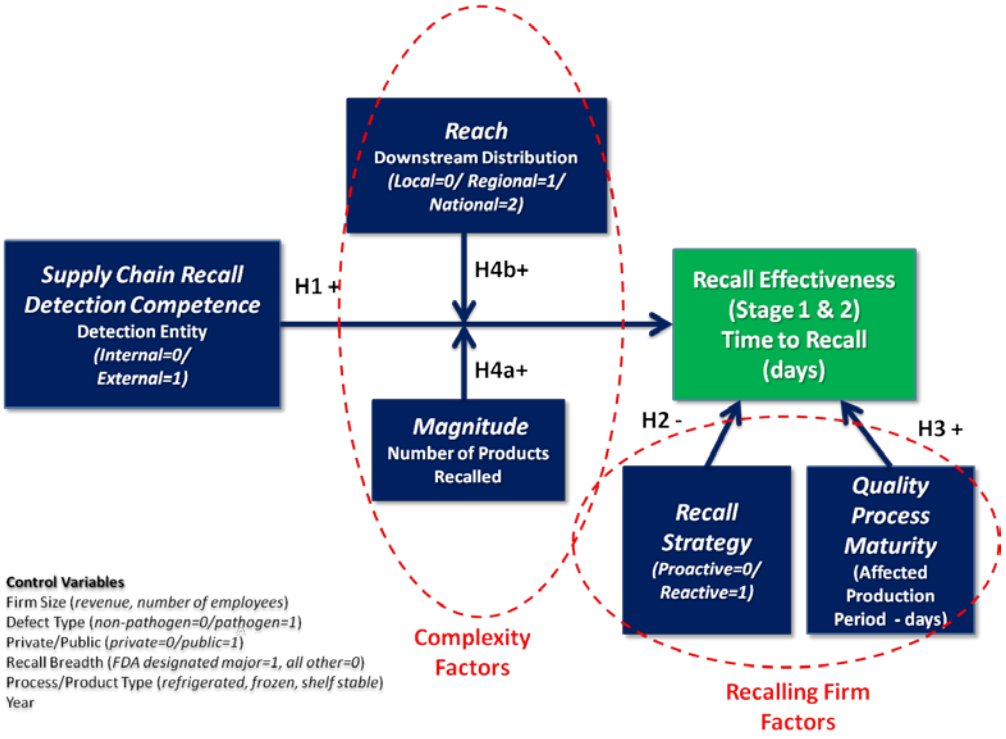
costs to the firm due to lost sales, reputational damage, warranty costs, reverse logistics, and product liability. Alternatively, internal failures lead to costs related to investigating failure, scrap and rework (Gryna, 1999). As a result, while firms have incentives to reduce both internal and external failure costs by investing in prevention and appraisal, minimization of external failures are typically considered the highest priority in terms of quality management.

We propose that the association of lower costs and higher performance associated with internal B2B supply chain failures applies to detection entity, meaning that higher performance – in terms of recall timing -- will be the outcome, on average, for internal detections, as compared with the external detections. Thus, SCRDC is a reflection, in part, of supply chain design, monitoring systems, communications, feedback mechanisms, and integration strategies that exist among supply chain entities that provide them the absorptive capacity to recognize quality problems in the first place; in addition to collectively resolving them faster (Cohen & Levinthal, 1990; Tu, Vonderembse, Ragu-Nathan, & Sharkey, 2006).

We evaluate the concept, in a sample of food recalls, for the detection of the underlying defect which results in a recall (and not resolution of the underlying defect or completion of the recall processes, including reverse logistics). We suggest that the SCDRC is an important factor in time to recall and may be more broadly applicable to other contexts. In addition, time to recall is a function of other supply chain factors, including complexity (i.e., the downstream "reach" of the recalls and "magnitude," represented by the number of different product specifications included in the recall) and

the recalling firm's relative *quality process maturity (QPM)*, as indicated by the period of the production time (in days) affected by the recalls. Figure 2.2 depicts our conceptual model and the relationships between the primary constructs used in this study, as well as our control variables. The hypotheses labeled in this figure are developed in Section 2.2.

Figure 2.2 Hypothesized Model



We test our framework using duration analysis methods applied to a database of recalls of FDA-regulated food products occurring between 2008 and 2010. We find that, in contrast to prior work examining recalls of durable products (Hora et al., 2011), proactive and reactive recall strategies have no direct effect on time to recall. Consistent with our expectations and the quality management literature, SCRDC matters (Gryna, 1999; Juran, 1992). Internally detected defects are associated with a shorter time to recall, *ceteris paribus*, than externally detected defects (Gryna, 1999; Ittner, 1992). These

results have implications for firms seeking to improve performance by improving internal supply chain detection capabilities through supply chain design, monitoring, communications and integration choices, and for policy-makers seeking to develop regulation and guidance that minimizes consumer risk.

The remainder of this paper is organized as follows. We first provide the motivation for our model, grounding our hypotheses in the extant literature and providing causal logic for relationships between detection entity, a proxy for SCRDC, complexity factors and QPM, in addition to other firm and product-level characteristics and the dependent variable, time to recall. We then describe the data collection process and empirical testing of our hypotheses. We follow with a discussion of the results of the empirical modeling, and finally, we provide implications for firms, as well as policymakers, and potential future research directions.

2.2 MOTIVATION & MODEL

2.2.1 Background

There are substantial differences between durable products and perishable products, like food, when such products are recalled. These differences are relevant, not only to the study of recall effectiveness as measured by recall timing, but also because differences between these categories of recalls influence the strategies which firms may employ to manage the recalls in terms of durable and perishable products when recalls occur. Table 2.1 summarizes some of these differences, which we discuss further in this section.

Table 2.1 Comparison of Durable and Perishable Products with Respect to Product Recalls

	Durable Products	Perishable Products
Example Products	Consumer products, medical devices, and automobiles	Food, pharmaceuticals, and cosmetics
Product Attributes	High testability, relatively long product life[10]	Low testability, relatively short product life
Failure Modality	More likely to be design-related than manufacturing-related (Bapuji, 2011; White & Pomponi, 2003; Hora et al., 2011).	Manufacturing-related[11]
Failure Attribution & Liability	Moderate to high attribution of failure by consumer to specific product. Liability can be very high, largely depending on the severity of the injury.	Low attribution of failure by consumer to specific product. Liability is high only when illness or death can be attributed to a product through investigation of an outbreak by the FDA/USDA/CDC.
Recall Strategy	More likely to be reactive than proactive	More likely to be proactive than reactive.
Detection Entity	Internal or External. Design flaws often first detected by consumers.	Internal or External
Reverse Logistics	Significant effort, particularly for products which must be returned for repair.	Some effort for pharmaceuticals which must be destroyed. Limited for food products, which are typically discarded at the consumer, retailer or distributor level.
Repair/Replace/ Retrofit/Refund	Repair is common for high-value durable products such as automobiles. Replacement or a retrofit kit (where safety modification is performed by the consumer) is also common for items such as consumer electronics and toys. Refunds occur as well, but less so for high-value durable items. Patients must coordinate with pharmacists or physicians to obtain alternative or replacement medical appliances.	Typically, refunds are provided for food products at the retail level. For pharmaceuticals, patients must coordinate with pharmacists or physicians to obtain alternative medications. Refund process may involve insurers when prescription medication is implicated.

[10] Disposable items such as alcohol preps (medical device) or batteries (consumer product), for example, might have a product life of a few years. Many durable items can be expected to have a much longer product life and may be resold (e.g., cribs, strollers, automobiles, toys). Pharmaceutical shelf lives for tablets average about 3 years. Sterile injectables typically are tested for a 1 year shelf life. Food products may have shelf lives from a few days (fresh fish) to a few years (canned high acid foods).

[11] When a pharmaceutical product is withdrawn from the market due to aftermarket safety issues (e.g., Vioxx), this is classified by the agency as a market withdrawal, not a product recall, and is governed by different regulatory processes.

In addition to the differences we discussed previously with respect to testability, failure modality, attribution of injury or illness to a specific product and recall strategy, whether it be proactive or reactive, and the nature of defect detection, a number of other distinctions exist between durable and perishable products. We suggest that these differences are important considerations for both product recall management and quality improvement.

First, as noted in Table 2.1, many durable products have a useful life that exceeds that of perishable products. Some products have extremely long potential useful lives and may be traded in the aftermarket (i.e., cribs, strollers, appliances, and automobiles). In contrast, perishable products can have extremely short to intermediate shelf lives (i.e., a few days for bean sprouts and up to 5 years or more for canned goods). This product life cycle has significant implications for the recall process since, as mentioned previously, delaying a recall announcement may actually reduce a firm's exposure to liability if it is difficult to trace illness back to the defective product. An automobile, on the other hand, may have a useful life extending into decades and multiple aftermarket owners, prolonging the firm's exposure to potential defects.

We next turn our attention to two interrelated issues of product recalls which contrast sharply between these types of products. Reverse logistics processes, as well as the type of reparation made to the consumer (repair, replacement, retrofit or refund), vary significantly, depending on the type of the product. For many durable products with significant value, some type of repair or replacement is typically undertaken; in some cases, finding a suitable "fix" for a defect is one factor in delaying the recall. In some

cases, a safety hazard is corrected by providing the consumer with a retrofitting kit which is self-installed. For more technically complicated failures, the reverse logistics could be extremely intensive: for example, when millions of laptop batteries overheated and had to be replaced, logistics costs were high due to the need to return defective batteries for reclamation, as well as the need to rapidly replace batteries to minimize consumer impact (Marks, 2006).

Scheduling and capacity to repair or replace is also an issue: for automotive recalls, the time to implement a remedy includes the design, manufacturing and distribution of new parts or the development of new procedures and scheduling with authorized dealerships, contingent on the capacity of dealership service departments (Anderson, 2010). In the medical device industry, firms must work with physicians and insurers to help achieve acceptable outcomes for patients with a potentially faulty pacemaker or other type of medical implant – a task complicated by the availability of replacement devices and underlying patient medical conditions.

For perishable products, reverse logistics are typically much less intensive, since for many recalled products at the consumer level, there is no provision for any return, only a refund. Furthermore, based on a recent survey related to food recalls, despite being generally aware of food recalls in the recent past, only 59% of respondents reported ever having looked for a recalled food in their home and only 9% reported returning the food or seeking a refund from a retailer (Hallman et al., 2009). In some cases, while products are still in the distribution channels, reverse logistics may be undertaken as part of the "take-back" and refunding process between producers, distributors and retailers.

However, in contrast with durable products, the recalling firm to consumer contact regarding the reparation is likely to be minimal for food. For pharmaceuticals, the issue of return and refund is complicated by the need to provide an appropriate substitute medication. For over the counter products, this may be a simple refund situation where the consumer selects a substitute without assistance. Nevertheless, in the case of a prescription medicine, insurers, physicians and pharmacists will be involved in the process. Again, the consumer to recalling firm contact is likely to be low, since the transaction is intermediated by insurers and healthcare providers. Still, the reverse logistics processes are significant, because recalled drugs are recovered and destroyed to the extent possible.

For the remainder of this paper, we will concentrate on the processes, regulations and factors affecting FDA-regulated food product recalls, specifically those factors which influence our dependent variable, time to recall.

2.2.2 Food Supply Chains & Product Recalls

While the US produces high volumes of food domestically, increasingly finished food products and ingredients for products manufactured in the US are sourced from around the world and handled in complex and far-flung supply chains involving numerous intermediaries (Institute of Medicine and National Research Council of the National Academies, 2010; Nestle, 2003; Roth et al., 2008ab). Globalization and consolidation are two factors known to drive the escalating number of food recalls.

Globalization, characterized by the involvement of global supply chain participants, as well as the import and export of finished products and ingredients, results in high

levels of supply chain complexity, in addition to challenging monitoring systems and reducing traceability and transparency (Bozarth et al., 2009; Choi & Krause, 2006; FDA, 2011a; Jerardo, 2008; Roth et al., 2008ab). On the other hand, consolidation of food production has arisen due to a combination of market pressures which have resulted in increasingly vertically integrated supply chains and the creation of very large public or private commercial entities which control large portions of specific market segments (Martinez, 2007; Nestle, 2003; Roth et al., 2008ab). Such consolidation concentrates the sourcing and production of food products, magnifying the potential consequences of a quality failure due to the high volumes of products that may be implicated (Institute of Medicine & National Research Council, 2010; Nestle, 2003; Osterholm, 2011; Roth et al., 2008ab).

Finally, as a result of both globalization and consolidation, food products have become increasingly commoditized and undifferentiated (Nestle, 2003; Roth et al., 2008ab). While food producers of processed finished products compete to add value in the form of convenience, taste or nutritional attributes to earn market premiums, commoditization increasingly occurs, not only at the ingredient level, but also at the finished product level, facilitated in many cases by increasing levels of contract manufacturing (Hughes, 2004). As an example, consider the common practice of retailers carrying "private label" branded goods, such as canned vegetables or soups labeled under their own brand name.

To achieve the economies of scale necessary to compete in the low margin food industry, it is now typical for a contract manufacturer, whose name remains largely

hidden to end consumers, to manufacture dozens of brands of similar products in the same facility with largely equivalent processes. The potential for this manufacturing model to result in widespread quality failures is illustrated in Roth et al. (2008ab), in their examination of pet food recalls starting in the year 2006, which resulted in the recall of hundreds of different brands of pet food, produced by the same contract manufacturer, using the same basic ingredient which was contaminated with melamine.

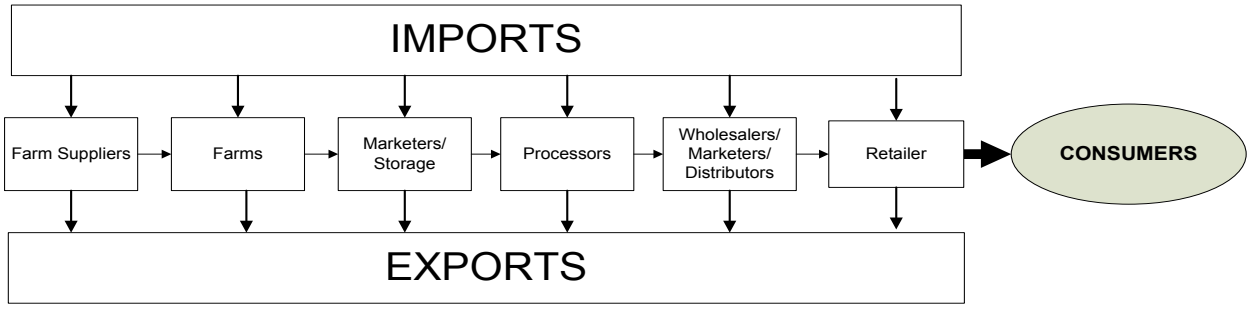
There is some evidence that contract manufacturers may pose a specific type of quality risk, based on the results of Gray, Roth and Tomlin (2012). These authors use a sample of FDA regulated pharmaceutical plants, demonstrating significantly higher levels of quality risk in contract manufacturers than in company-owned internal plants, on average.

Figure 2.3 depicts a generic and simplified single-ingredient food supply chain. As illustrated, the general structure flows from farm production, including suppliers to farms, which would include animal feed, fertilizers, seeds and other inputs, towards the end consumer. As a food product moves downstream, towards the customer, there are multiple opportunities for imported inputs to enter the supply chain, or for intermediate goods to be exported. Differentiation of more complex foods, such as convenience meals (frozen entrees, for example), increases as the food product moves through the supply chain towards the consumer. Despite the seemingly hierarchical nature of the supply chain depicted in Figure 2.3, upstream producers can directly reach the consumer (e.g., a farmer can directly reach a consumer or restaurant owner through a farmer's market).

The need to create economies of scale has driven supply chain players at both ends of the supply chain to vertically integrate and occupy more than one niche within the supply chain depicted in Figure 2.3. The Kroger Company, for example, while known predominantly in the US as a grocery retailer, owns 38 manufacturing and processing facilities which produce 40% of the private label goods sold in Kroger stores, including dairy, meat, beverages and shelf stable convenience foods (The Kroger Company, 2012).

Many large scale food production companies also occupy more than one niche within the supply chain depicted in Figure 3. Dean Foods, for example, both processes and distributes milk and dairy products, in addition to licensing its brand name to other firms. Additionally, large scale food producers often interact directly with retailers. General Mills, for example, supplies Wal-Mart directly, with Wal-Mart accounting for 23% of General Mills' annual revenue (Platt & Duronio, 2012).

Figure 2.3 Generic Food Supply Chain (Adapted from Roth et al., 2008b)



As indicated previously, in the US, the FDA regulates approximately 80% of food products sold, which comprises an estimated 75% of consumer food expenditures (GAO, 2004). FDA regulatory scope with respect to food products includes seafood, fruits, vegetables, dairy products, in-shell eggs and infant formula.[12] Egg products, meat and poultry are regulated by the USDA with enforcement and inspection activities, including recalls administered through the Food Safety and Inspection Service (FSIS). Memorandums of understanding between the FDA and USDA attempt to harmonize requirements for recalls and the reporting of food safety issues. The CDC, working with both the FDA and the USDA, gathers data on foodborne illnesses, leads investigations of potential outbreaks of foodborne illness, and monitors trends and the effectiveness of prevention and control initiatives (FSIS, 2012).

Because the focus of this study is on a sample of FDA-regulated recalled food products, we concentrate on FDA processes in the remainder of this paper; however, it is important to note that our findings may be generalizable to USDA-regulated products due to the similarity in regulatory systems, the structure of the industry and supply chain design.

Consistent with other agencies that regulate and recall products due to potential safety issues, the FDA classifies recalls with respect to the potential for creating a health hazard. Class I recalls are the most serious; they are considered to present a "reasonable probability that the use of, or exposure to, a violative product will cause serious adverse

[12] While the division of responsibility for regulating individual products can be non-intuitive (FSIS is responsible for liquid, frozen and powdered egg products, but the FDA is responsible for shell eggs. Mixture products, such as meat & cheese pizza versus cheese pizza may fall under different jurisdictions.), it is estimated that 85% of foodborne illnesses (due to foodborne pathogens) are attributed to FDA-regulated products (GAO, 2004a; Nestle, 2003).

health consequences or death" (US 23 Code of Federal Regulations 7.3(m)). Class II recalls are associated with product safety issues which "may cause temporary or medically reversible adverse health consequences or where the probability of serious adverse health consequences is remote" (US 23 Code of Federal Regulations 7.3(m)), while products subject to Class III recalls are considered unlikely to cause adverse health consequences.

Press releases are issued for Class I recalls and, in some cases, for Class II recalls when the defective product has been distributed to consumers. Our sample is comprised of all food recalls associated with a press release.[13] Press releases are written by firms and published via the FDA website and other media outlets, as deemed appropriate; in rare instances where the FDA deems the firm response to be inadequate, the agency will issue a press release. The following sections describe the dependent and independent variables used in this study and the causal logic for our hypotheses. Appendix 2A includes a detailed description of all constructs and definitions. Section 3 describes the data sources and data collection methods.

2.2.3 Time to Recall

Recent operations management research investigating a sample of toy recalls indicates that recall speed (time to recall), as measured by the time from the market introduction of a specific product until the recall announcement, is related to whether the recall strategy is proactive or reactive, the type of product defect, and the part of the supply chain that issues the recall (Hora et al., 2011). This research suggests that,

[13] In the full sample of food products (N=434), 13 recalls are Class II or Class III recalls. The majority of the sample consists of Class I recalls.

consistent with the prior evaluation of shareholder value impacts associated with product recalls, proactive recalls take longer than reactive recalls, in part, because firms have substantial incentives to delay recall notices (Hora et al., 2011).

For perishable products, we contend that it is more appropriate to study time to recall as the difference between the production date (beginning of shelf life) and the date of the recall announcement instead of the prior conceptualization using time to market introduction. This operationalization more closely reflects the time to recall construct with the nature of perishable products which have a finite shelf life which, in most cases, will be far more limited than the useful life of a durable commercial product. Part of the intent of a recall is to limit consumer exposure to an unsafe product (Hallman et al., 2009; Marsh, Schroeder & Mintert, 2004; Roberts, 2004, US Code of Federal Regulations 21.1.7.40(a)). As such, recall timing is arguably of even greater importance when the potentially hazardous product is perishable, or in other words, has a limited shelf life, since the more time that passes before a recall is announced, the more likely it is that the product will already have been consumed.

Time to recall can be calculated based on the date of the recall press release, product shelf life and product-specific information provided in the recall press release, indicating the date that the product will be considered "expired". In this context, expiration dates, sometimes known as "best by" or labeled as "guaranteed fresh until" dates, are determined by the manufacturer. There are no federal standards for how these dates should be determined or applied to products, although many states require that some sort

of dating be indicated on individual sale packaging. The formula for calculating the dependent variable is:[14]

$$T_i^* = Shelf\ Life_i - (Expiry_i - Recall_i) \quad \text{(Equation 1)}$$

where:

i represents the individual recall announcement (press release);
T_i^* is the number of days from the end of production to the date of the recall announcement;
$Shelf\ Life_i$ is the shelf life for the recalled product;
$Expiry_i$ is the expiration date of the product; and
$Recall_i$ is the date of the recall announcement.

Figure 2.1 illustrates the relationship between the beginning of shelf life at t=0 (end of production) and time to recall. Earlier recall announcements are preferred with respect to recall effectiveness, because potential consumer exposure is reduced when time to recall is shorter. This view of recall effectiveness is consistent with the perspective of consumers and policy-makers (reduced risk). Assuming that product failure is attributed to a specific product, shorter time to recall is also consistent with reducing the recalling firm's exposure to liability, due to a hazardous product (Packman, 1998).

2.2.4 Supply Chain Recall Detection Competence (SCRDC) and Detection Entity

The central proposition of this study is that our dependent variable, *time to recall*, is influenced by *detection entity*, which we argue is a proxy for the realized outcomes of superior SCRDC. SCRDC reflects a competence which resides within the recalling firm's internal systems, as well as between the recalling firm and its supply chain

[14] For the purposes of our study, we use the shelf life and date of expiration of the "earliest" expiring product in a specific recall announcement. The rationale for this choice is that the first product to expire within a given list of recalled products in a single announcement is most indicative of the relative timing of the recall announcement in terms of minimizing consumer exposure to potentially hazardous products.

partners. This multi-dimensional competence includes the manufacturing process, raw materials and finished goods monitoring systems, process auditing, and the integrative and coordinating mechanisms between supply chain partners.

The primary mechanisms for ensuring product quality are embedded within production processes (e.g., process design, maintenance, monitoring, inspection and testing, which occur prior to products being released for distribution). After a product is released for distribution, these mechanisms continue to operate, and, in some cases, identify a problem which implicates not only current production, but also prior released finished goods. Auditing production records, for example, can identify issues with temperature control, packaging, pH, and other critical process attributes which can affect production over a series of days, months or longer.

While the aforementioned detections may occur within a firm, there are also instances where systems between supply chain partners contribute to defect detection. In the previously described instance, where auditing production records uncover a defect, if the finished product were an input to another manufacturer's process, notification from the supplying firm to the purchasing firm would minimize the amount of downstream production volume affected. As a different example, in our sample, we observed anecdotal evidence of this competence being shared between different levels of the supply chain. In one product recall involving mislabeling, which resulted in allergens being present in a product without appropriate warning, the retailer notified the manufacturer of a potential problem when the product scanned incorrectly in the retailer's point of sale system. In this instance, in part because of the retailer's identification of a

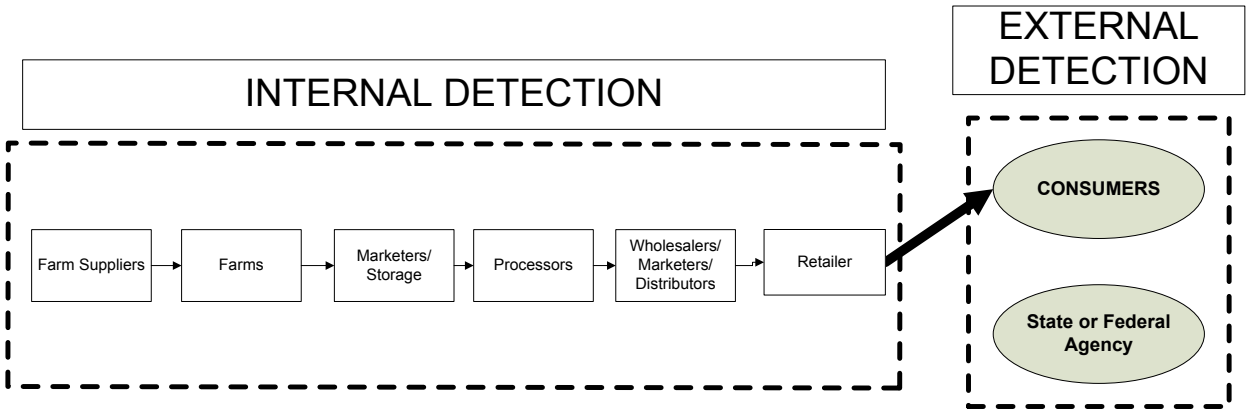
potential problem and subsequent communication to the manufacturer, the mislabeled product lot was traced and recalled prior to any reports of consumer ill effects.

In summary, we propose that SCRDC is the cumulative outcome of a series of choices by purchasing and supplying firms and relationships and systems between supply chain partners. Detection entity is therefore an outcome, in part, of the level of SCRDC that exists between purchasing and supplying firms, including processors, distributors and retailers.

Detection entity is operationalized as the entity that detects the defect which results in a product recall (*internal detection* indicated by defect detection by the recalling firm or its supply chain partners; *external detection* indicated by defect detection by a regulatory agency or a consumer). Consistent with the dominant logic of extant quality management theory, we would expect that defect detection that occurs further upstream in the supply chain would be preferable in terms of overall cost and other supply chain performance dimensions (Gryna, 1999; Ittner, 1992; Juran, 1992).

We, consequently, propose that more timely recalls (those recalls associated with a shorter duration or time to recall, controlling for other factors) will more likely be associated with upstream (internal) detections than by downstream entities (such as consumers or a regulatory agency, for instance, a state health department or the FDA). The continuum of possible detection entities is depicted in Figure 2.4.

Figure 2.4 Continuum of Detection Entities: Supply Chain Partners, Consumers and Regulatory Agencies (Adapted from Roth et al., 2008b)



Consistent with the quality management literature, product recalls, regardless of product type, are typically characterized as conformance quality or fitness for use issues (Juran, 1992). Notably, for durable products, there is evidence that *design flaws,* rather than *manufacturing defects,* make up the majority of defects causing recalls (Bapuji, 2011; Beamish & Bapuji, 2008; Hora et al., 2011; White & Pomponi, 2003). In contrast, food product recalls are almost exclusively due to defects that occur in manufacturing, storage or distribution.[15] Typical quality management programs have the objective of investing in prevention (quality planning, new product reviews, process planning & control, audits, supplier evaluations, and training) and appraisal (inspections, testing of inputs, work in process, and finished goods) activities to reduce the occurrence of internal and external failures.

[15] In our examination of FDA food recalls, we noted one exception to the source of the defect, manufacturing, rather than design. In some cases, supplements are manufactured with harmful levels or fraudulent ingredients. These failures may be related to design defects, rather than manufacturing defects.

Internal and external quality failures are typically evaluated in the literature in terms of the cost of quality (COQ) (Crosby, 1979; Crosby, 1984; Juran, 1972). While internal failures cause costs related to scrap, rework, missing information, failure analysis, reinspection, retesting and redesign, external failures cause costs related to warranty claims, complaint resolutions, returned goods, reverse logistics, refunds, future discounts, and – most importantly – lost sales due to customer defection and reputation damage (Gryna, 1999). Because external failures are so costly, even more so than internal failures, quality management programs typically prioritize the minimization of external failures.

Consequently, quality theory prioritizes external failures over internal failures based on the logic that external failures are more damaging to the enterprise in the long term than internal failures (Gryna, 1999; Ittner, 1992; Juran, 1992). Furthermore, evidence from the economics literature suggests that the indirect costs associated with product recalls (lost sales, shareholder value losses, brand equity losses) are greater than the direct costs associated with warranty work, logistics of returns, complaint investigations and legal liability (Jarrell & Peltzman, 1985; Rupp, 2003). This notion is consistent with the commonly held view that COQ are often "hidden" or difficult to measure or reliably quantify (Cokins, 2006; Crosby, 1979; Gryna, 1999; Juran, 1992).

As further support for our hypothesis, we offer logic grounded in information processing theory literature (Galbraith, 1974). When failures are detected externally, the information processing and coordination that must occur for the recalling firm to first, be notified, and to second, organize their response, is greater than the information

processing required by internal detections. Recalls are handled by exception; in contrast, the communication of quality issues between B2B and within firms is routinized. However, when detection comes from a consumer, or the agency, non-routine processes are involved. More specifically, whether a consumer reports a defect to a producer or a regulatory agency, a process of investigation and verification must occur prior to action. Therefore, we associate consumer detection with a longer time to recall.

We also argue that agency detections require a level of information processing within the agency prior to communication with the firm. While the agency, by policy and design, is intended to act quickly to protect public health, a positive test result is the first step towards potential enforcement action. Consequently, the agency may be more methodical and slower in their actions, than internal firm communications or communications between a buyer and supplier with coordinated information sharing. We contrast this with an internal detection, where a positive test result or an internal inspection that finds a problem. Routines exist to process internal detection quickly and efficiently, even between firms assuming that effective contractual and relational governance systems are in place. While this logic is relatively intuitive when applied to detection by the recalling firm, we argue that it is also applicable to detection by suppliers to the recalling firm, since the barriers to coordination between a supplier and buyer will be less than those between a recalling firm and consumer or regulatory agency.

We propose that recalls detected by external entities (*detentbinary=1*) are reflective of lower levels of SCRDC and will have a longer time to recall, on average, than recalls

detected by internal entities (*detentbinary*=0), which are reflective of higher levels of SCRDC. More formally:

HYPOTHESIS 1 *Higher levels of supply chain recall detection competence are associated with shorter time to recall, ceteris paribus.*

Appendix 2A describes the operationalization of the detection entity in detail. Appendix 2A also contains a detailed description of the coding protocol and provides examples of press release statements which correspond to each detection entity categorization.

2.2.5 Proactive & Reactive Recall Strategies

Recall strategies, as conceptualized in the product recall literature, have been characterized relative to whether or not illness or injury has been associated with the defective product at the time of the recall (Chen et al., 2009; Hora et al., 2011). *Proactive recall strategies* are indicated when no injuries or illnesses related to the defective product have been confirmed prior to the recall. In contrast, *reactive recall strategies* are indicated when injury or illnesses have been confirmed as being related to the defective product prior to the recall. Proactive recall strategies have been associated with delays in recalls in prior studies (Chen et al., 2009; Hora et al., 2011).

Hora et al. (2011) argue that the time to recall (as measured by the difference between the time of the product introduction and the recall announcement date) will be greater for preventative recalls than reactive recalls. Their reasoning includes firms having incentives to delay recalls to preserve the stock price (Chen et al., 2009) and because a preventative recall occurs in the absence of concrete information about injury or illness attributed to the product defect.

However, as discussed previously, foodborne illnesses are greatly underreported and rarely attributed to a specific defective product. As a result, we suggest that the numbers of food recalls announced with illnesses attributed to them are also underreported. We also suggest that the theoretically predicted effect of proactive/reactive recall strategies (*reactive*=1; proactive=0) might be smaller in the food sector than in many durable product categories. We believe this, since failures that cause food recalls are considered to be potential regulatory violations and required to be reported to the FDA within 24 hours of detection. Nevertheless, the incentives attributed to firms in prior studies which might drive the delay of recalls also apply in this context. Being consistent with the literature, we now hypothesize that:

HYPOTHESIS 2 *Proactive recalls will be associated with a greater time to recall than reactive recalls, ceteris paribus.*

2.2.6 Quality Process Maturity (Affected Production Period)

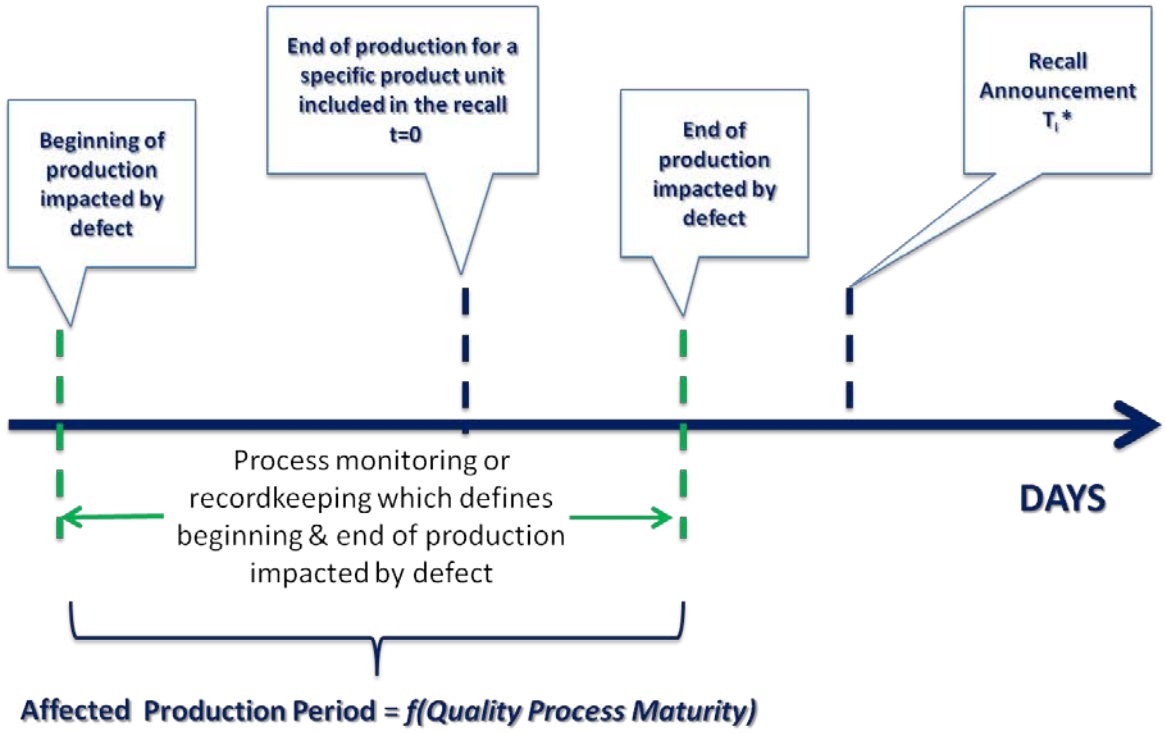
Whether a recalled food product is produced in small, crafted batches (e.g., handmade chocolate) or in large volumes (e.g., nearly continuous production runs, such as canned goods), when the product is recalled, it has an *affected production period* associated with it. This *affected production period* represents the time frame of production affected by the underlying defect which caused the recall. Figure 2.5 depicts the concept of the affected production period, bounded by quality monitoring information that defines when the problem began (or when it can be reasonably assured to have been absent) and when the problem ended.

Where the monitoring of processes for defects is particularly infrequent and production is semi-continuous and occurring in large volumes, the affected period could stretch into years (e.g., Setton Pistachios recalled nearly two years worth of pistachios after issues at its production facility and contaminated finished products triggered a recall). Alternatively, when the defect is highly discrete, such as the application of incorrect labels missing allergen information, the affected production period might be as small as one day's worth of manufacturing. As affected production periods grow longer, the number of days between the first affected product and the last becomes longer. As a result, the longer the affected production period, the greater we would expect the time to recall to be for a specific product.

We propose that the affected production period is a proxy for the *QPM* of the recalling firm, because longer production periods affected by defects are indicative of less robust quality systems, both in terms of prevention and appraisal (Crosby, 1979). This analogy is consistent with the Quality Management Process Maturity Grid proposed by Crosby (1979), which contains five stages of maturity: uncertainty, regression, enlightenment, wisdom and certainty. The latter three stages, enlightenment, wisdom and certainty, mark an organization's transition from identifying and resolving quality problems routinely to defect prevention to processes that are consistently zero defect and operate with a consistently high level of conformance quality (Crosby, 1979).

HYPOTHESIS 3. *Quality Process Maturity is associated with a longer time to recall, ceteris paribus.*

Figure 2.5 Affected Production Period (Proxy for Quality Process Maturity)



2.2.7 Supply Chain Complexity

Increasing product and supply chain complexity and trends towards increased outsourcing, rather than vertically integrated manufacturing, have diffused the responsibility for initial component quality (that is, the initial quality of an individual component or ingredient of a larger product or mixture) across multiple organizations and geographic regions (Gray et al., 2009a; Gray et al., 2011b; Lyles et al., 2008; Roth et al., 2008ab). This diffusion has a perverse multiplier effect in that it simultaneously renders the detection of potential defects more difficult, creates incentives among supply chain members for deception and shirking, and increases the complexity of product recall implementation and product recovery.

In our study, we identify three different "complexity factors" which represent aspects of supply chain complexity that affect time to recall. These factors are: *recall magnitude* (number of different product specifications included in a single recall announcement), *recall reach* (extent of downstream distribution of the recalled product) and *recall breadth* (an indicator of the association of the recall with a broad failure that impacts many downstream firms). These factors are consistent with extant conceptualizations of supply chain complexity; principally, the idea that "the distinct number of components or parts that make up a system" (Bozarth et al., 2009, p. 79), is a starting point for recognizing increasing levels of complexity.

2.2.7.1 Moderating Effects of Recall Magnitude

When products are recalled, it is not unusual for more than one size, formulation, or variety of a product to be included in the same recall announcement. This is particularly true for food products, where the nature of processes and inputs is such that a single defect (e.g., salmonella contamination, either in the processing equipment or introduced by an input) can easily affect multiple products. In some cases where a single contract manufacturer produces multiple brand names, the recall announcement may contain multiple brand names, sizes, packaging and specification of affected products.

We conceptualize the number of products recalled as a proxy for one possible dimension of the amount of information processing a recalling firm must perform to announce, with some reasonable level of certainty, what products are affected by a specific defect. In food recalls, the recall announcement contains a list of products

affected. The number of products in a recall announcement is readily determined from each press release.

When a recall is detected, either by an internal or external entity, the known information about the defect (e.g., what type of problem, which product the defect was detected in, how the defect was detected – by testing, inspection) is communicated within or to the recalling firm. We propose that the level of information processing required to coordinate determining which products, lots, batches and production dates are affected is a function of both the detection entity and the number of products recalled. We believe this since the number of products recalled introduces a level of complexity that must be managed for the recall to be announced.

Due to regulatory requirements demanding that recalls be announced within days of the discovery of a defect, information processing must be conducted with on-hand resources. In other words, there is no time for adjustments to the organization's structure or information processing resources after the defect is detected (Galbraith, 1974). We believe that, because recalls are rare events, it is unlikely that slack resources are dedicated to handling them. This issue is analogous to the concept of "complicatedness," introduced by Vachon & Klassen (2002), to describe situations where required information exists within the organization, but the volume of information may overwhelm processing capabilities.

Vachon & Klassen (2002) provide evidence that product variety (as captured by the number of products recalled), can have negative effects on supply chain performance, including inventory levels, lead time and delivery performance (Bozarth et al., 2009; Lee,

Padmanabhan & Whang, 1997; Vachon & Klassen, 2002). Consequently, we would expect, on average, for the number of products to influence the effect of detection entity on time to recall. More specifically, we expect that higher numbers of products within a recall announcement will positively moderate the effect of SCRDC on time to recall, rendering detections by internal or external entities less effective, on average, in terms of time to recall.

HYPOTHESIS 4a *The effect of SCRDC on on time to recall is positively moderated by the recall magnitude.*

2.2.7.2 Moderating Effects of Recall Reach (Downstream Distribution)

Product recall announcements, used to inform the public as to where affected products are expected to be found, makes a note of the states in which an affected product was distributed. Within the US, we characterize the distribution of finished goods as *local* (1-3 states), *regional* (4-20 states) or *national* (>20 states). Appendix 2A contains the details of how this variable was coded.

Similar to the number of products recalled, we expect that the extent of the distribution of recalled products will have an amplifying effect on the relationship between the detection entity and time to recall. As with increasing numbers of recalled products, we would expect that a more widespread distribution of finished goods will increase the information processing burden on the recalling firm to determine where the affected products were sold (Galbraith, 1974). This logic is consistent with Bozarth et al. (2009) and Vachon & Klassen (2002), who established the negative effects of the increasing levels of supply chain echelons, and broader geographic spans of customers, as negatively affecting the supply chain performance.

Downstream distribution may be a proxy for the geographic extent of the distribution and the complexity introduced when the number of downstream supply chain partners increases. More specifically, we expect that more broadly distributed products within a recall announcement will positively moderate the effect of SCRDC on time to recall, rendering detections by internal or external entities less effective, on average, in terms of time to recall.

HYPOTHESIS 4b *The effect of SCRDC on time to recall is positively moderated by recall reach.*

2.2.7.3 Recall Breadth

The third complexity factor included in our study is conceptualized as a control variable. *Recall breadth* is an indicator of the size of the recall with respect to the number of firms impacted. In 2008, the FDA began designating recalls which affected many different products and many different firms with the term "major". While this term has no regulatory meaning, the FDA has used this term to categorize recalls which require additional communication measures due to the breadth of products and firms impacted (FDA, 2009).

There have been, to date, a total of five FDA-designated "major" recalls, all of which occurred between 2008 and 2010. These include: powdered milk (2008), peanuts (2009), pistachios (2009), shell eggs (2010), and hydrolyzed vegetable protein (2010) (FDA 2009b).

We operationalize *recall breadth* as a binary indicator (*recallbreadth*=1, associated with a major recall; *recallbreadth*=0, not associated with a major recall) which indicates whether a particular recall announcement is linked to a major recall. We expect that a

greater recall breadth, which involves recalls that affect dozens, or even hundreds, of firms and up to thousands of different products, will be associated with a longer time to recall. This is due to the cascading notifications and coordination between firms supplying a defective ingredient, regulatory agencies, heavily involved in "major" recalls, and the firms conducting the recalls. We are also interested in determining if our model is robust to estimation using recalls that are not associated with "major" recall events, by including a model which only examines non-major recalls (*recallbreadth*=0).

2.2.8 Additional Control Variables

We control for multiple variables that we expect will influence time to recall. Due to the wide variation in shelf lives, we expect that a large proportion of the variability in time to recall will be attributable to the product type. We control for product type by developing three categories: refrigerated, frozen and shelf stable (*cat0_refridge*, *cat1_frozen*, *cat2_shelfstable,* respectively). These categories capture the attributes of the products themselves, including variability in shelf life and the aspects of the underlying processing and storage characteristics. We also include several variables which reflect the aspects of the recalling firm, including the public or private status of the firm (*public*=1, private=0) and two indicators of firm size: annual revenue and number of employees (*firmrev* and *firmempl*).

Publically traded firms, due to requirements for reporting various aspects of operations, and due to the transparency of such operations to shareholders and the wider public, may also be more systematic in their monitoring of processes and suppliers. Larger firms typically have more resources; hence, larger firms might be expected to

improve performance with respect to recall timing (longer remaining shelf life). However, consistent with prior studies, publically traded firms may have incentives to delay recall announcements, therefore reducing the remaining shelf life. We also control for defect type (0=non-pathogen; 1=*pathogen*) and the year the recall was announced (*yr_2008*, *yr_2009*, *yr_2010*) (Hora et al., 2011).

2.3 RESEARCH DESIGN

2.3.1 Sample Frame and Data Sources

This study uses secondary data collected from publically available sources to construct a database of recall events for FDA-regulated food products over a three year period (See Table 2.1A, Appendix 2A for details of individual variable definitions and data sources).

The unit of analysis in this study is a recall event. A *recall event* (henceforth referred to as a *recall*) is defined as an individual press release announcement of a recall of one or more affected products. The sample frame for this study is the set of product recalls for food products regulated by the FDA over the period of 2008 through 2010 for which firm press releases were made and published on the FDA website. Due to our focus on perishable foods subject to common recall administration systems, infant formula, subject to separate recall requirements, was excluded.

The time period covered by this study includes a period of relatively consistent policy and regulatory enforcement by the agency with respect to these types of product recalls. This time period includes the sharp increase in the total number of food products beginning in 2009 (Lister & Becker, 2010). This time frame also includes the beginning

of the FDA's use of the designation "major" for recalls which, for a variety of different reasons, may lead to the agency conducting expanded communications.

FDA policy dictates communication of product recalls through two different mechanisms: 1) a weekly agency-issued enforcement report which lists all product recall actions for the past week; and 2) firm-issued communications to the public, downstream customers, distributors and retailers. According to FDA guidance, when the product has already been distributed to the consumer level and there is a potential for a significant health hazard, a press release is considered appropriate. The FDA publishes these press releases on their website and has archived press releases for recall events from the year 2004 through the present time (see Appendix 2A for examples of press releases and enforcement reports).

Enforcement reports summarize recalls by week and by recall class. These reports include the recalling firm name, a description and list of the recalled products (size or weight, packaging, any labeling as to lot codes, expiration, production or distribution dates), a reason for the recall (defect type, also sometimes confirms detection entity), volume of the product in commercial distribution, states in which the product has been distributed, and the status of the recall as of the date of the enforcement report.

Press releases are made by the recalling firm and published on the FDA website in addition to being released to other media outlets. The FDA has issued guidance regarding the content of the press release; however, the actual content of the press releases varies substantially in terms of the level of detail provided. Agency guidance recommends that the announcement include the recalling firm name, location (city and

state), product identification information (including any codes, expiration dates, lot/unit numbers), a description of what is currently known about the problem and any health hazard associated with the defect, the number of illnesses associated with the defect that have been confirmed at the time of the recall, information on what consumers should do with the recalled product, and where to find additional information.

2.3.2 Data Collection

Data were collected by accessing the FDA's online archives of weekly enforcement reports and press releases for food products for the years of 2008 through 2010. Enforcement report information was merged with press releases to develop an initial set of 1,602 press releases for consideration. Because the dependent variable is a measure of recall timing, we exclude any press releases which do not contain enough information about the production, distribution or expiration dates necessary to calculate the dependent variable. This reduces our sample to a total of 846 press releases.

The remaining press releases and enforcement reports were coded by three different persons using a set of scales developed during a pilot analysis of 100 press releases, and refined over time, to ensure internal consistency and external validity. Approximately 20% of the total sample was coded by more than one person in order to check for consistency. Inter-rater reliability was high (>97%) and all cases where disagreement occurred were readily resolved through discussion among the raters.

The central independent variable for this study, *detection entity*, is not reported in all press releases. This omission further reduces our sample to 434 food product recall cases. After the inclusion of all specified regressors and control variables, the final

sample consists of 258 product recall announcements. Appendix 2A summarizes all constructs and measures used in this study and provides additional detail regarding data collection and coding.

2.3.3 Calculation of Time to Recall and Sample Descriptives

Time to recall (T_i^*) is measured in days and is calculated based on the shelf life of the earliest expiring individual product specified in a given recall announcement and the date of the recall announcement relative to the expiration date of the product, consistent with Equation 1[16]. We illustrate the calculation of time to recall for our prior examples:

Example 1: Concentrated beverage

T_i = 732 days – (June 17, 2008 – September 23, 2009)*

T_i= 732 – 463 =* ***269 days*** *from the end of production to the recall announcement date*

Example 2: Cut, fresh, packaged produce

T_i = 21 days – (October 20, 2010 – January 22, 2010)*

T_i= 21 – (- 271) =* ***292 days*** *from the end of production to the recall announcement date*

Table 2.2 summarizes the descriptive statistics for the variables included in our model. We note that, consistent with our expectations of duration data, there is a strong skew in the dependent variable (*timetorecall*). Appendix 2A provides additional descriptive information for the sample.

[16] $T_i^* = Shelf\ Life_i - (Recall\ Announcement\ Date_i - Expiration\ Date_i)$ (Equation 1)

Table 2.2 Descriptive Statistics

Construct	Variable Label[1]	Description	Mean	Standard Deviation
Public	**Public**	*0/1 private/public status of recalling firm*	.136	.343
Firm Size	**Firmrev**	*Recalling firm revenue in millions of dollars*	4,097.235	15,464.0
	Firmempl	*Recalling firm employees*	13,951.59	51,583.79
Recall Breadth	**Recallbreadth**	*0/1 non-major/major status of recall, as designated by the FDA*	.814	.390
Recall Strategy	**Reactive**	*0/1 indicating proactive/reactive recalls*	.124	.330
Supply Chain Recall Detection Competence (Detection Entity)	**Detentbinary**	*Detection entity 0/1 indicates internal/external defect detections*	.128	.335
Quality Process Maturity (Affected Production Period)	**prodperiod**	*Number of days defect occurred undetected*	231.252	288.232
Recall Magnitude (Number of Products Recalled)	**noproducts**	*Number of products in the recall announcement*	6.713	10.568
Product Type	**cat0_refridge**	*0/1 dummy for fresh/refrigerated products*	.097	.296
	cat1_frozen	*0/1 dummy for frozen products*	.116	.321
	cat2_shelfstable	*0/1 dummy for shelf stable products*	.787	.410
Defect Type	**pathogen**	*0/1 for indicating non-pathogen/pathogenic defects*	.895	.307
Recall Reach (Downstream Distribution)	**local**	*1-3 distribution states*	.198	.399
	regional	*4-20 distribution states*	.240	.428
	national	*>20 distribution states*	.562	.497
Time to Recall (days)	**timetorecall**	*Days from the beginning of the shelf life to the date of the recall announcement*	350.752	322.172
Year	**yr_2008**	*Year dummy for recalls occurring in 2008*	.081	.274
	yr_2009	*Year dummy for recalls occurring in 2009*	.864	.343
	yr_2010	*Year dummy for recalls occurring in 2010*	.054	.227

1. Variable label as it appears in Stata.

2.3.4 Model Specification

Our study examines factors which influence *time to recall*, a dependent variable (T_i^*) which captures the time, in days, between the beginning of the shelf life and the date of the recall announcement. Because our dependent variable is a span of time, we propose to use a duration (survival) model to address several aspects of our data which may render an estimation by the ordinary least squares (OLS) model inappropriate (Cameron & Trivedi, 2005; Harhoff & Wagner, 2009; Hosmer, Lemeshow, & May, 2008; Kalbfleish & Prentice, 2002; Terwiesch, Ren, Ho, & Cohen, 2005). Duration data is often skewed, which violates the standard OLS assumption that the dependent variable is normally distributed, conditional on the independent variables. Furthermore, an OLS model does not bound the predicted value of time to recall, which could result in predicted values of time to recall negative, and consequently, infeasible. Finally, duration analysis provides the flexibility to explicitly model unobserved heterogeneity which, if significant and unaccounted for, could produce erroneous or biased results. Table 2.3 summarizes the duration models which comprise our analysis.

Table 2.3 Parametric Duration Model Summary

Model	Sample Restrictions	Distributional Assumptions	Unobserved Heterogeneity (Frailty)	Comments
Model 1a	None	Log-normal	None	Examine models for the consistency of direction & the significance of the results. Check for relevance of higher order terms not explicitly hypothesized.
Model 1b	None	Log-logistic	None	
Model 1c	None	Weibull	None	
Model 2	None	Consistent with Model 1a-1c results	Modeled using gamma and inverse Gaussian distributional assumptions	If unobserved heterogeneity is significant, those estimates will be preferred. Choose Model 1 or Model 2 to use for robustness checks.
Model 3	Limited to recalls that are not FDA-designated as "major" (*recallbreadth*=0)	Consistent with Model 2 results	Consistent with the results of Model 2	Examine model for consistency between major and non-major recalls (Compare Model 1b and Model 3).

The analyzed models are single-spell continuous time duration model, meaning there is only one transition event:

Product Not Recalled $\longrightarrow$ Product Recalled

This is a duration (survival) analysis where all cases within the sample experience the event of interest (a product recall announcement). In addition, a shorter time to recall (i.e., shorter survival time), or, in other words, a greater hazard rate, is preferable over a

smaller hazard to reduce consumer risk and minimize firm liability due to consumer illness. Analysis time is equal to the duration in our model (T_i^*), the time to recall measured from t=0, defined as the end of production for the earliest expiring product within a given product recall announcement (beginning of shelf life). Time to recall is strictly positive. There is no censoring in our sample and the regressors do not vary over time (i.e., they are time-invariant over the duration of a specific case which results in a recall).

Duration models are specified in terms of survival and hazard functions. A survival function is the cumulative proportion of the sample that does not experience the transition event (in this case, the recall announcement), or the probability that the duration to the transition event is equal to at least *t*. Conversely, the hazard function represents the probability that the duration to the transition event is *t* or less.

The conditional density is a function of t, conditioned on **X** and θ, where:

X = time-invariant regressors

Θ = a parameter vector

Using a maximum likelihood estimation, the contribution to the likelihood is found to be the conditional density. The density for the *i*th observation (where i is an individual product recall announcement) can be written as:

$$S(t_i|X_i,\theta) \qquad \text{(Equation 2)}$$

The maximum likelihood estimator maximizes the log likelihood:

$$\ln L(\theta) = \sum_{i=1}^{N} \ln f(t_i|X_i,\theta) \qquad \text{(Equation 3)}$$

assuming independence over *i*.

In terms of the integrated hazard function, this can be written as:

$$\ln L(\theta) = \sum_{i=1}^{N} \Lambda(t_i|\boldsymbol{X}_i, \theta) \qquad \text{(Equation 4)}$$

More specifically, the model can be formulated as a proportional hazards (PH) model or an accelerated failure time (AFT) model. A PH model is written as:

$$h(t|X_j) = h_0(t)\exp(X_j \beta_x) \qquad \text{(Equation 5)}$$

where $h_0(t)$ is the baseline hazard and is assumed to follow a distribution based on the conceptualization of the underlying hazard. Alternatively, an AFT model is parameterized as:

$$\ln(t_j) = X_j\beta_x + \xi_j \qquad \text{(Equation 6)}$$

where a distribution is assumed for $\exp(X_j\beta_x)$, also known as the acceleration parameter. When the acceleration parameter is greater than zero, failure becomes increasingly likely with time, *ceteris parabus*. Accordingly, when the acceleration parameter is one, time passes at a "normal" rate. When the acceleration parameter is less than one, failure becomes less likely with time, *ceteris parabus*. We use the AFT model specification, in part, because it enables us to directly compare all three of our conceptually-justified distributional assumptions.

Our model, in AFT form, is specified as:

$$\begin{aligned}\ln(t_j) = {} & \beta_{DetectionEntity}X_j + \beta_{Public}X_j + \beta_{FirmRevenue}X_j + \beta_{FirmEmployees}X_j + \beta_{Breadth}X_j \\ & + \beta_{Reactive}X_j + \beta_{QPM}X_j + \beta_{Magnitude}X_j \\ & + \beta_{ProductCategory}X_j + \beta_{Pathogen}X_j + \beta_{Reach}X_j + \beta_{Year}X_j + \beta_{DetectionXReach}X_j \\ & + \beta_{DetectionXMagnitude}X_j + \beta_{BreadthXQPM}X_j + \xi_j\end{aligned}$$

(Equation 7)

2.3.4.1 Distributional Assumptions

Based on our understanding of recall processes and monitoring for defects and illnesses associated with defects in food products, we would expect that, over the shelf life of a given product, the distribution of recall announcements could be expected to increase or be relatively constant early in the shelf life, and to decrease later in the shelf life period. We base this on the rationale that process monitoring and auditing closer to the end of production for a given product is arguably more relevant to detecting a defect than later monitoring. In addition, our assumption is generally supported by the shapes of the survival curves developed by the non-parametric estimation of the detection of defects in meat and poultry processing plants by Teratanavat et al. (2005). Our assumed distribution could be represented with a log-normal, log-logistic or Weibull distribution.

Parametric estimation of duration models can be sensitive to specification of the density function (Cameron & Trivedi, 2005). Therefore, we estimate a series of parametric duration models using these three distributional assumptions which we consider conceptually justified. Models 1a, 1b and 1c estimate time to recall using the AFT specification and log-normal, log-logistic, and Weibull distributions, respectively. We find consistent results in terms of the direction and significance of the coefficients. As such, we conclude that the specification is not sensitive to distributional assumptions within the three distributions considered. Appendix 2B contains the results for all distributional assumptions.

2.3.4.2 Unobserved Heterogeneity (Frailty)

Duration models, like other types of statistical models, are vulnerable to misspecification, including the inadvertent omission of relevant predictor variables (Cleves, Gould, Gutierrez, & Marchenko, 2010; Hosmer et al., 2008; Kalbfleisch & Prentice, 2002). To guard against misspecification, we test for the relevance of a variety of higher order terms, in addition to estimating a model which incorporates unobserved heterogeneity, also known as frailty. The hazard for an unshared frailty or unobserved heterogeneity model can be written as:

$$h(t_j|X_j, \alpha_j) = \alpha_j h(t_j|X_j) \qquad \text{(Equation 8)}$$

where α_j is an unobserved case-specific effect. The survival function can, consequently, be written as:

$$S(t_j|X_j, \alpha_j) = \{S(t_j|X_j)\}^{\alpha_j} \qquad \text{(Equation 9)}$$

where $S(t_j|X_j)$ is the parametric survival function. Modeling explicitly for this unobserved heterogeneity accounts for differences between cases not captured in the variables included in the model. Consequently, if we find evidence of a significant frailty effect, we would conclude that there are factors that significantly affect time to recall that are unobserved, and therefore omitted, from our model. The estimation of the frailty effect, however, allows the model estimates to account for this unobserved heterogeneity, if necessary (Hosmer et al., 2008).

To estimate the model expressed by Equation 9, a distribution is assumed for α_j. For the purposes of tractability, typically a gamma distribution or an inverse-Gaussian

distribution are assumed (Cameron & Trivedi, 2005; Cleves et al., 2002). When α_j is assumed to follow a gamma distribution with a mean of 1 and a variance equal to Θ, the survivor function can be written as:

$$S_\theta(t_j|\boldsymbol{X}_j) = [1 - \theta ln\{S(t_j|\boldsymbol{X}_j)\}]^{-1/\theta} \quad \text{(Equation 10)}$$

Alternatively, if the inverse-Gaussian distribution is assumed, the survivor function can be written as:

$$S_\theta(t_j|\boldsymbol{X}_j) = exp\left\{\frac{1}{\theta}\left(1 - [1 - 2\theta ln\{S(t_j|\boldsymbol{X}_j)\}]^{1/2}\right)\right\} \quad \text{(Equation 11)}$$

Consequently, if unobserved heterogeneity is negligible, Θ goes toward zero and the model estimation without the unobserved heterogeneity term is preferred (Cleves et al., 2010).

Because the results of the three conceptually-based distributional assumptions are largely consistent, the choice of the estimated models is irrelevant. We proceed with an additional estimation and interpretation using the log-logistic assumption. Incorporating unobserved heterogeneity results in a preference for the model without frailty, since the unobserved term is not statistically significant under either gamma or inverse Gaussian distributional assumptions (χ^2 = 0.00 p<1.00, see Appendix 2B for full results). In Section 4, we interpret the results of the final models.

2.4 RESULTS

2.4.1 Model 1b Estimates

Table 2.4 illustrates the results of the final estimated models, while Table 2.5 summarizes the results of our hypothesis testing. Model 1b is the log-logistic AFT model

which includes all the hypothesized relationships, in addition to the higher order term Recall Breadth X Affected Production Period, which, during misspecification checks,

Table 2.4 Model Estimates: Unstandardized Coefficients & Average Marginal Effects (AME)

Construct	Model Variable/Proxy	Model 1b Full Sample		Model 3 Recall Breadth=0	
		Coefficient	AME[2]	Coefficients	AME[2]
Public/Private	Public	**-.439***	**-107.949***	.006	.494
		[.338]	[81.885]	[.847]	[75.954]
Firm Size	Firm Revenue	4.31 X10^{-6}	.018	.00003	.069
		[6.57 X 10^{-6}]	[.027]	[.00004]	[.078]
	Firm Employees	-1.90 X 10^{-6}	-.019	-4.13 X 10^{-6}	-.035
		[2.72 X 10^{-6}]	[.027]	[.00001]	[.129]
Recall Breadth	Recall Breadth	**1.538****	**378.458****	--	--
		[.293]	[87.595]	--	--
Recall Strategy	Reactive	.078	19.168	.091	8.146
		[.207]	[50.894]	[.339]	[30.405]
SCRDC	Detection Entity	**1.304****	**320.921****	.372	33.405
		[.529]	[132.907]	[.406]	[36.652]
QPM	Affected Production Period	**.003****	**.624****	**.003****	**.277****
		[.001]	[.233]	[.001]	[.112]
Recall Magnitude	Number of Products (Magnitude)	.006	1.427	**.009****	**.830****
		[.006]	[1.386]	[.004]	[.414]
Product Type	Cat1_frozen	**1.802****	**443.507****	**2.146****	**192.436****
		[.554]	[147.549]	[.678]	[77.162]
	Cat2_ShelfStable	**2.079****	**511.717****	**1.024****	**91.862****
		[.421]	[113.427]	[.422]	[36.542]
Defect Type	Pathogen	-.002	-.402	-.316	-28.362
		[.444]	[109.154]	[.313]	[27.911]
Recall Reach	Regional (Reach)	.187	45.986	-.269	-24.102
		[.301]	[73.890]	[.526]	[47.455]
	National (Reach)	.034	8.484	**-.723****	**-64.844****
		[.267]	[65.677]	[.328]	[34.410]
Year	Yr_2009	.188	46.204	.355	31.861
		[.422]	[103.982]	[.407]	[37.997]
	Yr_2010	.023	5.591	-.020	-1.764
		[.443]	[108.93]	[.487]	[43.643]
SCRDC X Reach	Detection X Regional	-.808	--	.077	--
		[.545]	--	[.613]	--
	Detection X National	-.530	--	.435	--
		[.574]	--	[.715]	--
SCRDC X Magnitude	Detection X Number of Products	-.002	--	.011	--
		[.014]	--	[.012]	--
Recall Breadth X QPM	Recall Breadth X Affected Production Period	**-.002****	--	--	--
		[.001]	--	--	--
	Constant	**1.796****	--	**2.892****	--
		[.655]	--	[.399]	--

(*significant at p<.10, **significant at p<.05)

Note 1: Robust standard errors specified are reported below each estimate in parentheses. Robust standard errors were estimated using *firmcluster*, an indicator assigned to each unique firm present in the sample. This allows for the correlation of error terms across clusters of recall announcements conducted by the same firm. There are 201 unique firms in our sample of 258 product recalls.

Note 2: Average marginal effects (AME) reported as dy/dx for all values except for Firm Revenue and Firm Employees, reported as elasticities.

was determined to be significant. Model 3 mirrors Model 1b, except that the sample has been restricted to those recalls not associated with a FDA-designated "major" recall (*recallbreadth*=0) to check for the robustness of the model.

Positive coefficients are indicative of longer durations with increasing values of that regressor. For categorical regressors, a positive coefficient is indicative of longer durations, as compared with the reference category. In our conceptualization, a longer survival time corresponds to a longer time to recall, which is less desirable than a shorter time to recall for a similar product in terms of reducing consumer exposure to potentially defective products.

In Model 1b, SCRDC as measured by the proxy, detection entity, is significant and positive, providing support for Hypothesis 1, and indicating that externally detected (consumer or agency) failures have a longer time to recall, on average, than internally detected (supplier or recalling firm) failures. Greater recall breadth (*recallbreadth*=1), as expected, is associated with greater time to recall, controlling for other factors. Product categories are significant predictors of time to recall. As expected, refrigerated products have a much shorter time to recall than frozen or shelf stable products, on average, due to their shorter shelf lives.

For the purposes of visualizing the differences between internal and external detection, we compare survival curves graphically. Figures 2.6, 2.7 and 2.8 depict the survival curves for internal and external detection entities and refrigerated, frozen and shelf stable product categories, respectively. The y axis of the survival curve is the *probability* that the product recall has not occurred by time t. The x axis is the *analysis*

time, the duration in our model; t=0 represents the end of production for each recall event. Refrigerated products, consistent with their shorter shelf lives, have very steep survival curves which begin to flatten out towards 0 at t~365 days. In each case, when comparing internal and external detection entities for each product category, we note a flatter survival curve for the external detection entity (which is more pronounced for frozen and shelf stable products than for refrigerated products), which demonstrates that the internal detection entity, consistent with higher levels of SCRDC, is preferred. This result is consistent with quality theory, relative to time to recall performance.

Figure 2.6 Survival Curves for Refrigerated Products

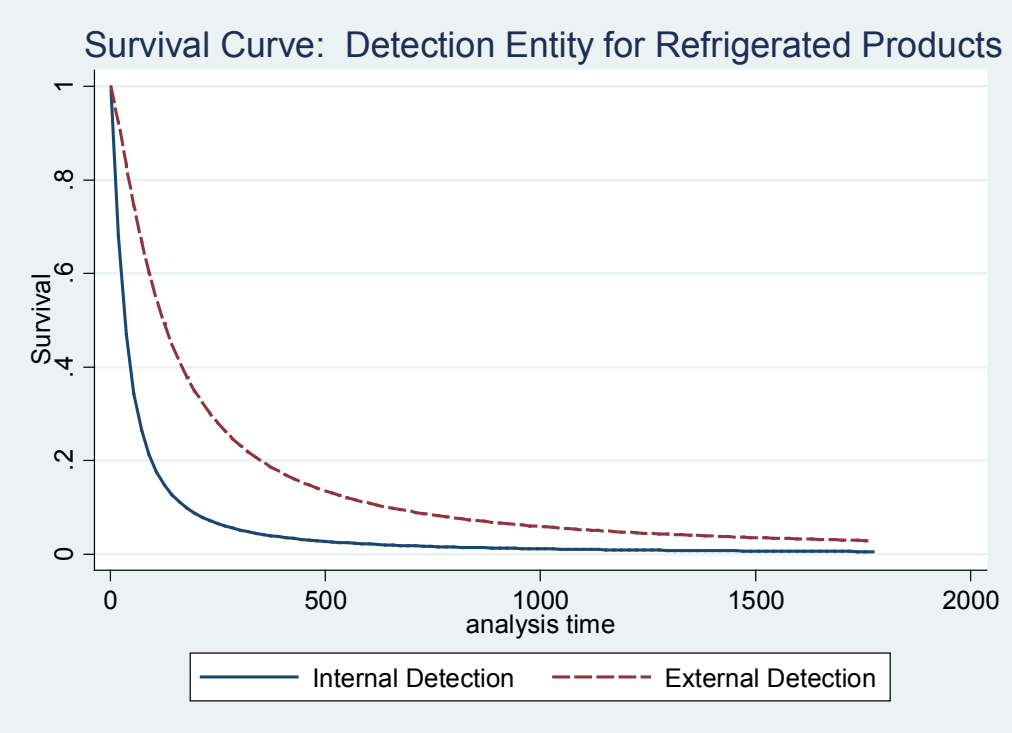


Figure 2.7 Survival Curves for Frozen Products

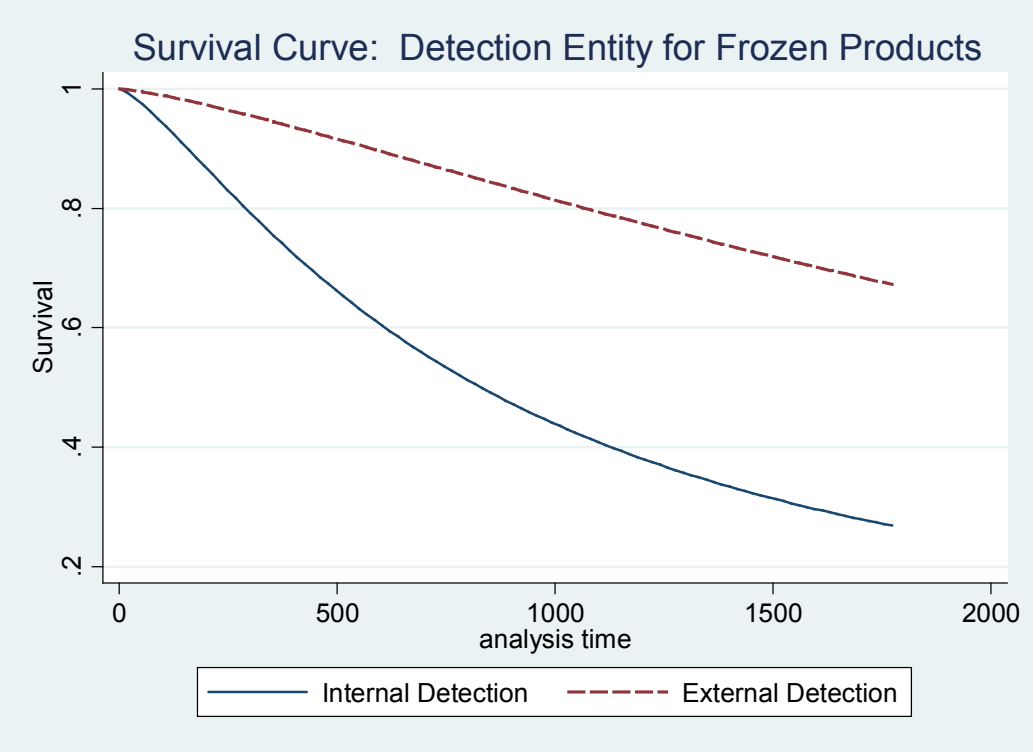


Figure 2.8 Survival Curves for Shelf Stable Products

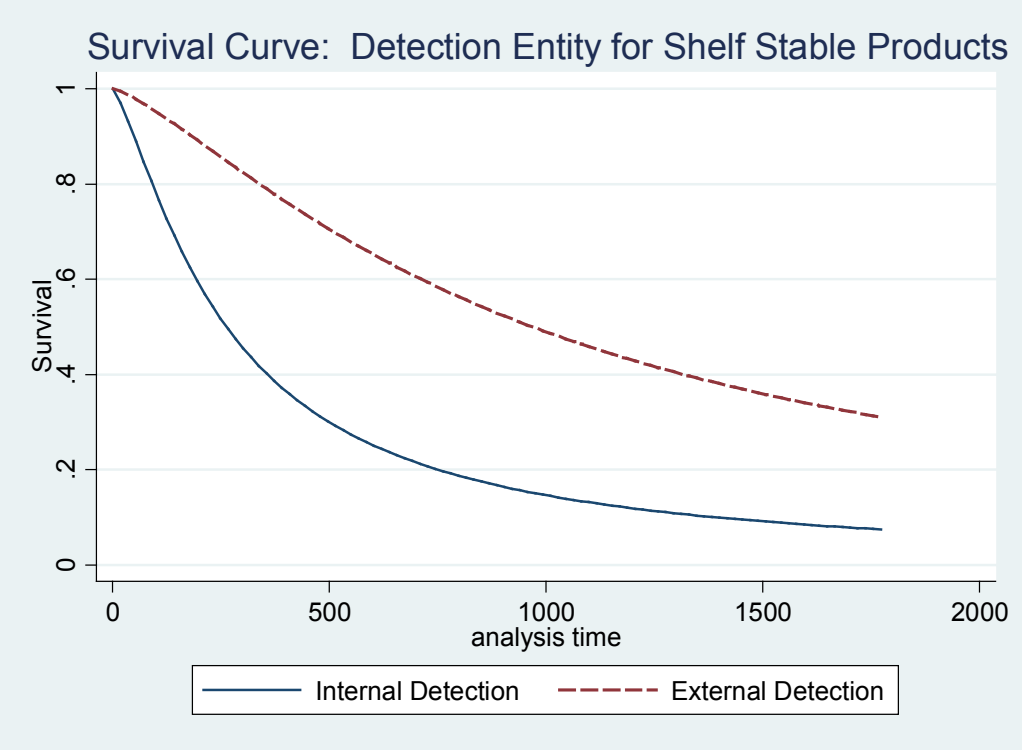
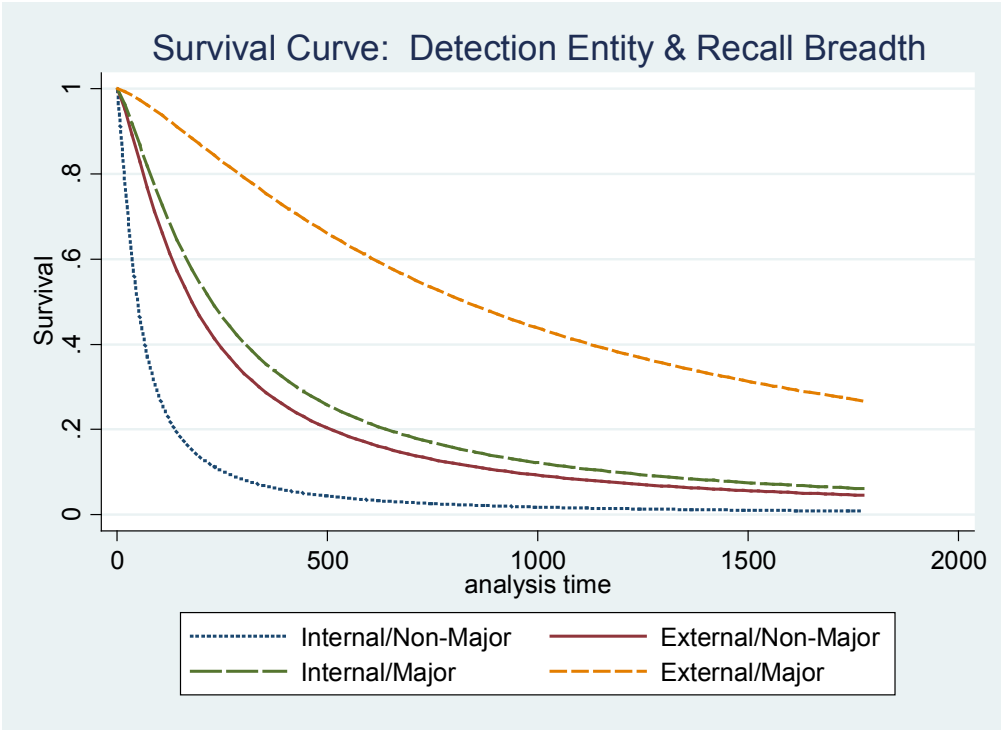


Figure 2.9 presents a comparison of the survival curve for different values of detection entity and recall breadth. As expected, time to recall occurs at a faster rate for internal/non-major (*recallbreadth*=0) events than for external/major (*recallbreadth*=1) events. This is consistent with our understanding of the primary effect of detection entity and the nature of greater recall breadth. Greater recall breadth (FDA designated "major" recalls) is indicative of broad impacts across many different products and firms. We suggest that recall breadth negatively impacts time to recall due to issues with coordination between regulatory entities and recalling firms. When an upstream supply chain entity is responsible for a defect that leads to recalls in many different downstream products across multiple firms, the downstream product recalls are delayed by the

notification process between the original recalling firm and the downstream recipients of the defective material. When the breadth of the recall is sufficiently large, such that the FDA designates a need for special communication efforts, time to recall is significantly impacted, as is evidenced by the flattening of the two uppermost survival curves in Figure 2.9.

Figure 2.9 Survival Curves Comparing Detection Entity & Recall Breadth



Public/private status was used as a control variable (*public*=1, private=0). Model 1b results indicate that there is a negative effect of public status on time to recall (significant at a $p<.10$ level). While our firm size controls of firm revenue and the number of firm employees are not significant, the nearly significant result of public status may be indicative of more sophisticated traceability systems in larger, publically traded firms.

The estimated effects of defect type (*pathogen*=1, non-pathogen=0), direct effects of recall reach (downstream distribution - *Local*, *Regional* or *National*), year dummies and recall magnitude (number of products - *noproducts*) included in the recall announcement were not significant in Model 1b.

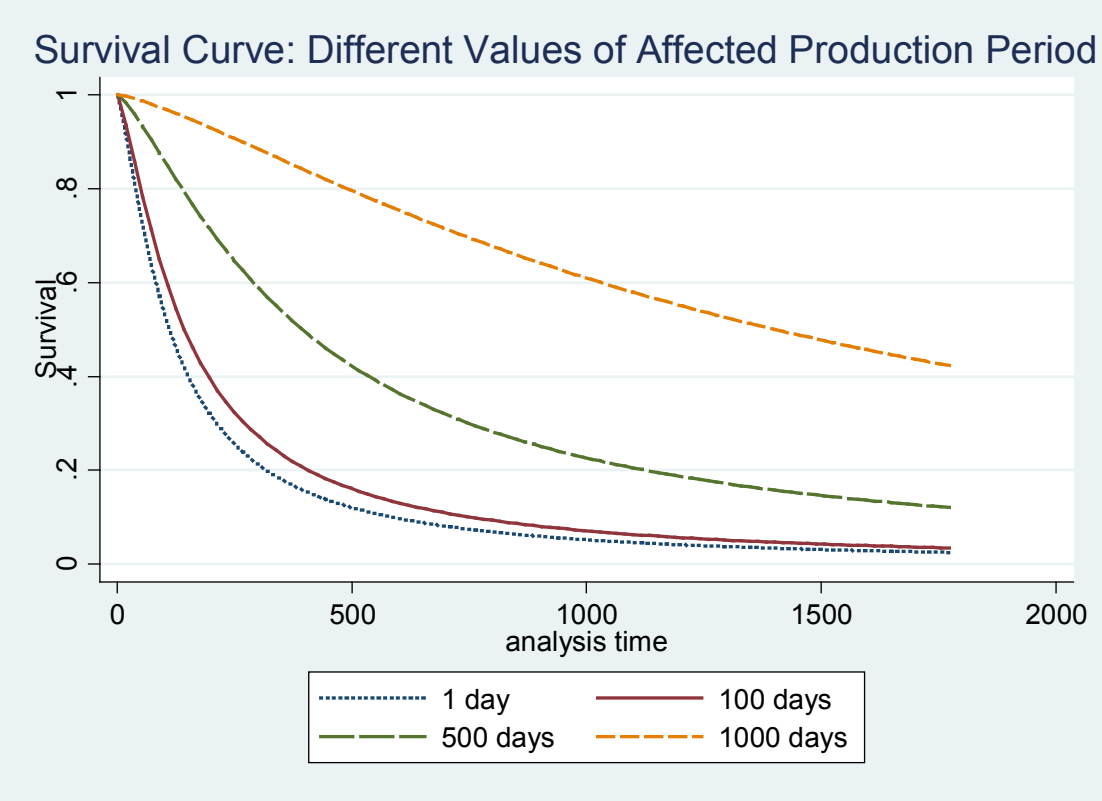
We do not find significant effects of the interaction between detection entity and recall magnitude or recall reach. Consequently, Hypotheses 4a and 4b are not supported. This may be indicative of what has been reported to be the relatively high level of downstream traceability present in the US food system. In other words, when recalls happen, the number of products recalled and the breadth of downstream distribution do not affect time to recall because downstream traceability is well developed. It is noteworthy to mention, however, that upstream traceability, or the ability to trace inputs back to their point of origin, particularly with respect to imported ingredients, is not similarly well developed, and consequently, quality systems for the US food supply are vulnerable to undetected upstream defects. As such, US producers may need to adjust their monitoring systems accordingly.

Contrary to prior work in the context of toy (durable product) recalls, we do not find a significant affect of proactive/reactive recall strategies on time to recall, indicating that Hypothesis 2 is not supported (Hora et al., 2011). As discussed previously, the nature of food quality issues lends itself to the under-attribution of illness to specific products. As such, the traditional proactive/reactive recall strategy characterization may be of limited usefulness for food products.

Prior work has suggested that publically traded firms may have substantial incentives to delay recalls until more information is available (reactive strategy) (Chen et al., 2009). While we do not find a significant effect in our sample of proactive/reactive strategies on time to recall, we note that similar incentives are likely to exist for both public and private food producers, and that, furthermore, the limited ability of the current systems to attribute illness to specific products could encourage firms to hide defects until external detections force a recall.

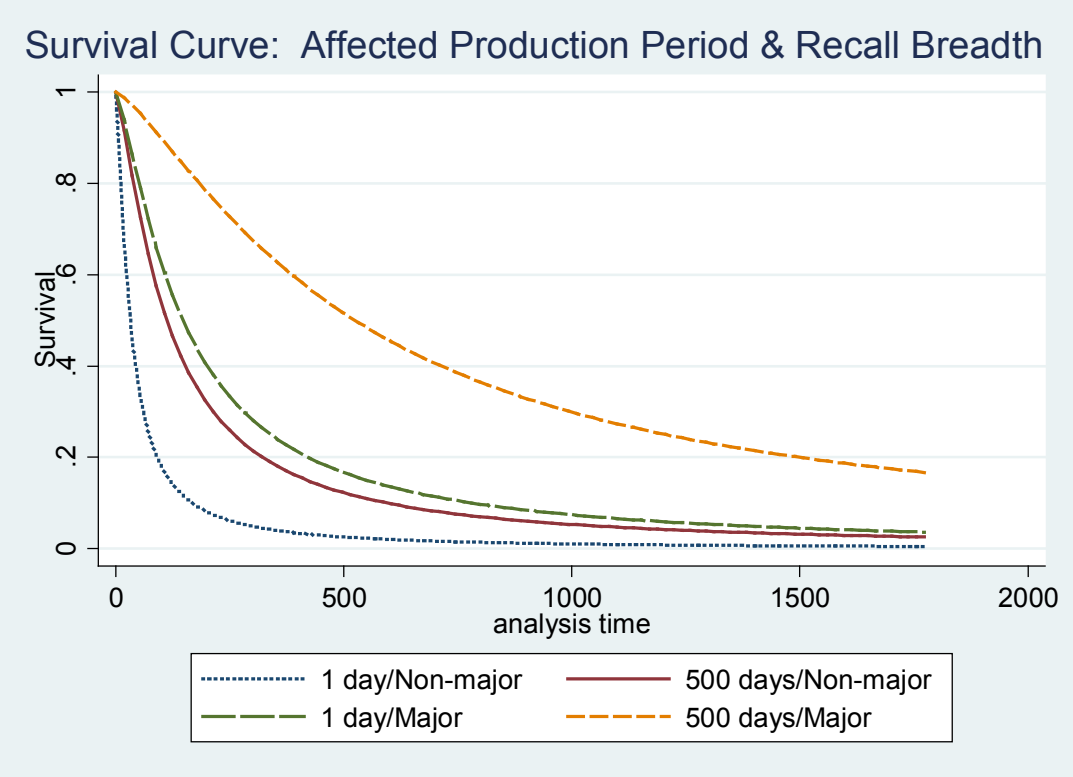
We find a significant and positive effect of QPM as measured by the proxy, affected production period (*prodperiod*), indicating, in support of Hypothesis 3, that as defects go on for longer periods of time, the corresponding time to recall is extended. Figure 10 illustrates the survival curves for selected values of the affected production period (1 day, 100 days, 500 days and 1000 days).

Figure 2.10 Survival Curves for Selected Values of QPM (Affected Production Period)



If we plot the survival curves for the same values of QPM (affected production period=1 day and 500 days) for low and high recall breadth (*recallbreadth*=0, non-major recall; *recallbreadth*=1, major recall), we can note the steep survival curve for high QPM (1 day) combined with low recall breadth as compared with the much flatter survival curve for low QPM (500 days) combined with high recall breadth (Figure 2.11). The steeper curve indicates a shorter time to recall, controlling for other factors and is, consequently, indicative of greater consumer risk reduction.

Figure 2.11 Survival Curves for Selected Values of QPM (Affected Production Period) and Recall Breadth



2.4.2 Model 3 Robustness Check for Recall Breadth

Due to the recent prevalence of very broad recalls with extensive effects on many products and firms (e.g., FDA-designated major recalls), a large proportion of the sample is associated with "major" recalls. We are interested in determining if our estimates are sensitive to eliminating that portion of the sample related to major recalls. We conduct an additional analysis for the subset of recalls not designated as major (Model 3; *recallbreadth*=0) to check the robustness of our results. Table 2.4 summarizes a comparison of the coefficients and average marginal effects across the full sample (Model 1b) and sample restricted (Model 3) models.

Due to sample size restrictions (N=48), our ability to make an inference from Model 3 is limited, however, the results, in general, are consistent with Model 1b, with a few exceptions. We discuss these exceptions, as follows. The effects of firm size (firm revenue & number of firm employees), proactive/reactive recall strategy, affected production period, product category, defect type (pathogen), year dummies and interaction terms are consistent between Models 1b and 3. Model 3's estimates do not include a significant result for publically traded firms; however, we are limited not only by the sample size for Model 3, but also by the limited presence of public firms in that sample (5 firms out of 48 are publically traded). Model 3 indicates a statistically significant direct effect between nationally distributed products (recall reach) and time to recall. This result lends some support to the finding that nationally distributed products are recalled more quickly than regionally or locally distributed products, possibly because national distribution networks are accompanied by well developed traceability capabilities which enable for the quicker identification of affected products.

The number of products recalled (recall magnitude) has a significant and positive effect on time to recall in Model 3, indicating that, as the number of products in recall announcement increases, time to recall increases. This may indicate that, for low recall breadth, the recall magnitude has significant effects due to the higher information processing and coordination requirements of managing a recall with more affected products (Galbraith, 1974).

Finally, Model 3's estimate of the effect of SCRDC (detection entity) on time to recall is not statistically significant ($z=.80$ $p<.421$). We suspect that this result is due to

the limited sample size and number of regressors included in the estimation. When we drop the interaction terms and re-estimate Model 3, we find the SCRDC coefficient to be positive and significant (at $p<.08$), which is consistent with Model 1b. Because we can find no compelling conceptual or theoretical explanation for the effect of SCRDC to be different in a sample of recalls not associated with a major recall, we suggest that Model 3's results are consistent with Model 1b, but limited by sample size.

Table 2.5 Hypothesis Testing & Results Summary

Hypothesis Number	Hypothesis Statement	Results	Basis
H1	Higher levels of SCRDC are associated with shorter time to recall.	Supported	Detection entity is positive and significant in Models 1a, 1b, 1c and 2. Detection entity is positive and significant at p<.08 in Model 3, when interaction terms are dropped due to the limited sample size.
H2	Proactive recalls will be associated with a greater time to recall than reactive recalls.	Not Supported	Reactive is not significant in Models 1a,1b, 1c, 2 and 3.
H3	Quality process maturity is positively associated with longer time to recall.	Supported	Detection entity is positive and significant in Models 1a, 1b, 1c, 2 & 3.
H4a	The effect of SCRDC on time to recall is positively moderated by recall magnitude.	Not Supported	Interactions are not significant in Models 1a, 1b, 1c, 2 & 3.
H4b	The effect of SCRDC on time to recall is positively moderated by recall reach.	Not Supported	

2.5 DISCUSSION

2.5.1 Contributions

In aggregate, the extant literature reflects the recall timing paradox which firms conducting product recalls and public policy-makers charged with ensuring an acceptable level of public safety face. This paradox indicates that while the corporate crisis communications and marketing literature support the idea of conducting recalls proactively to manage consumer opinion and influence customer loyalty (Dawar &

Pilluta, 2000; Laufer & Coombs, 2006), publically traded firms may face substantial and prolonged market penalties as a result of the product recalls, and may, in fact, benefit from delaying the recall until more information is available (Chu et al., 2005; Chen et al., 2009). Overall, however, the results are mixed regarding the extent to which market forces (in the form of short-term abnormal shareholder returns) provide incentives for firms to act in a manner which promotes a desirable level of public safety (Chu et al., 2005; Chen et al., 2009; Thirumalai & Sinha, 2011, Thomsen & McKenzie, 2001). In short, the evidence is unclear as to what strategies and policies are best suited to balance tradeoffs between direct and indirect impacts to firms due to product recalls and to ensure that the public is appropriately protected from the physical and financial losses due to unsafe products.

This study examines factors that influence recall timing in a context which has not been studied previously – the FDA-regulated food sector. Time to recall is an important dimension of recall effectiveness, to the extent that more timely recalls reduce consumer risks, firm costs including liability, and costs to society.

Our first hypothesis regarding SCRDC is supported. This result suggests that, consistent with quality theory, directing prevention and appraisal activities towards internal detection of defects contributes to one dimension of recall effectiveness – recall timing. We argue that SCRDC as reflected by detection entity is a realized outcome of *a priori* supply chain design and monitoring choices made by the recalling firm and its supply chain partners. To the extent that these choices build a superior ability to detect and resolve quality issues within each firm and across supply chain partners, we suggest

that the resulting competency benefits supply chain partners by enabling a shorter time to recall. This competence, which we do not fully explore here, may have other benefits; supply chains with high levels of SCRDC may also perform well against other measures of recall effectiveness, including liability minimization, reverse logistics costs and volume recovered.

Prior operations management proactive/recall strategy characterizations, although hypothesized to be consistent with the prior literature (Hora et al., 2011), do not have an effect on time to recall in this study's context. This result, which conflicts with prior findings (Chen et al., 2009; Hora et al., 2011), is an indication of the very different nature of quality failure and product recalls in the food product context, as compared with durable products. In addition, the difference in the proportion of recalls reactive in the food sector, as compared with the durable product recalls, highlights how the true impacts of food quality issues are largely obscured, particularly from the point of view of the consumer. While this study focuses on product recalls as observable external quality failures in this particular industry, we suggest that our findings, particularly with respect to SCRDC and QPM, may be generalizable to other contexts, including durable products.

2.5.2 Managerial & Policy Implications

We suggest that firms seeking to improve both recall effectiveness and reduce the risk of external quality failures examine their supply chain design and monitoring systems, since these choices will ultimately affect their ability to prevent or detect failures before they leave the control of the firm. We propose that monitoring system design should be considered holistically across supply chain partners, rather than being confined internally

to a single firm. The significant and positive effect of QPM (affected production period) on time to recall underscores what quality theory would suggest: that impacts of uncontrolled, undetected defects become increasingly severe over time with respect to recall effectiveness. This finding, coupled with the significance of SCRDC, reinforces the importance of evaluating monitoring systems in light of their internal single-firm processing characteristics and the processing and monitoring systems of their suppliers.

We suggest that, with respect to pathogenic contamination, which is the current leading cause of product recalls, this recommendation is particularly relevant for firms that receive high volumes of bulk ingredients or intermediates from other firms and further process them into finished goods in semi-continuous processes (Golan, Krissoff, Kuchler, Calvin, Nelson & Price, 2004; Hughes, 2004; Kumar & Budin, 2006; Teratanavat & Hooker, 2001). Furthermore, this study provides evidence that the quality monitoring associated with a specific product unit may include ongoing quality monitoring activities after the release of the product for distribution. In addition, these "after the fact" activities, including document review, process testing and supplier communication, play a role in recall effectiveness as defined by time to recall.

Because we expect that recalls will continue to be an unfortunate necessity, firms that wish to differentiate themselves in the otherwise highly commoditized food industry may find that improved recall effectiveness and, eventually, recall prevention through conscious supply chain design and monitoring choices, including increased testing, auditing and cooperative relationships with suppliers, may increase their value proposition. This aspect of quality system implementation could be considered a form of

corporate social responsibility, since product recalls impose health hazards on consumers and costs to consumers individually and society as whole (Roberts, 2007; Scharff, 2011).

Our findings regarding SCRDC support the effectiveness, in the context of product recalls, of industry self-monitoring. This is the central principle of many regulatory enforcement systems, including that of the FDA. In the case of food product recalls, the industry's own monitoring is more effective than detection by a regulatory agency or a consumer with respect to recall timing. In other words, while regulatory agency oversight is critical to holding firms accountable, it is not timely; consequently, incentives need to be aligned to promote internal monitoring. Policy-makers may need to consider regulations and policy which can provide incentives to firms to conduct more internal monitoring and to focus on enforcement and compliance support efforts based on the risk of contamination, compliance risk and the likelihood of affecting downstream facilities.

In addition, the severity of impacts across firms and poor time to recall performance of high recall breadth events (FDA-designated "major" recalls) highlights the importance of targeting enforcement towards upstream commodity providers. However, in addition to these findings (that agency enforcement activities are not as effective as supplier or recalling firm monitoring with respect to time to recall), FDA and similar agencies will continue to be challenged by resource constraints. As a result, the development and implementation of regulations which improve incentive alignment in this industry and other product safety contexts is critical to public health and safety.

2.5.3 Limitations & Future Research

Our study is not without limitations. We are limited by the nature of the available data in several ways. Secondary data require that the researcher identify the constructs of interest and then determine if the data or suitable proxy measures are available to match those constructs. Inevitably, there are constructs of interest that are not available, and proxies, which while justified, are imperfect measures of the underlying construct (Roth, Gray, Shockley & Weng, 2009). In some respects, we avoided some of these issues by defining specific constructs, such as detection entity, *a priori*, and then coding the press releases according to the specified definition. Some of our measures can be considered objective (e.g., number of products recalled). In other respects, however, our data could be criticized due to the use of potentially imprecise measures of shelf life, approximated measures (firm revenue, firm employees) and, in some cases, the restricted sample size due to missing data. Furthermore, the nature of product recalls is such that we cannot construct a true panel dataset with repeated measures for firms over a number of years, which restricts our analysis to time invariant predictors.

This analysis is conditioned on the population of food products that were recalled over the time period of our sample; we do not observe food products that were not subjected to recalls, which could be considered a form of right censoring. Nevertheless, we believe that this model makes an important contribution with respect to disentangling some of the firm, product and supply-chain related factors that influence time to recall when a food product recall occurs.

2.6 CONCLUSIONS

This study provides new and contrasting findings regarding the nature of factors that influence time to recall in the context of food products. This work is relevant to academia, industry, and policy-makers. Given the ongoing trends towards increasing levels of disintermediation, complex, long supply chains, contract manufacturing, importation and concerns about terrorism and counterfeiting, it can be argued that new sources of safety issues will continue to arise (Lyles et al., 2008; Roth et al., 2008ab). As a result, conducting effective product recalls will continue to be of interest to consumers, industry and policy-makers.

In addition to the ubiquitous nature of food, the conformance quality attributes of food products are largely credence attributes and are difficult, or impossible, for consumers to verify prior to purchase (Darby & Karni, 1973; Nelson, 1970; Roth et al., 2008ab). Consequently, the industrial and regulatory systems that ensure quality in these product categories are the primary safeguard against product harm due to conformance quality failure. As a result, understanding the effectiveness of these systems in removing potentially harmful products from the hands of consumers is an important societal issue. Both industry and governmental agencies have responded to this trend, both by increasing traceability and testing systems and regulatory requirements and enforcement activities (FSIS, 2010; FDA, 2011a). Nevertheless, more work is necessary to ensure that scarce resources are directed towards areas where the most benefit can be realized (FDA, 2011b).

This study is part of a larger program of research and suggests multiple directions for additional study. We believe that additional insights could be gained by applying the framework of detection entity to other product contexts, including pharmaceuticals, which can also be considered perishable products. As detailed in Appendix 2A, we identified four distinct potential detection entities: regulatory agencies, consumers, recalling firms and suppliers, to recalling firms. We believe that an investigation which parses out the relationship between different types of detection entities and recall timing in a variety of perishable and durable product contexts would be useful for generating additional insights into differences between durable and perishable products and quality failure issues.

Our study does not delve into issues between the recalling firm and suppliers, although we recognize that there are likely to be principal-agent issues with respect to the supplier reporting of quality issues. Additionally, food producers face particular challenges with respect to appraising quality and preventing external failures, since quality attributes cannot always be tested or inspected (Roth et al., 2008ab).

The limits of "testability" in food and pharmaceutical products have become painfully obvious in recent years due to the delayed discovery of substitute ingredients in pet food (melamine) and heparin (oversulfated chondroitin sulfate) (FDA, 2010a). In light of the well-known limitations of testability and increasing threats to food safety, there is an urgent need to investigate which monitoring and governance structures are most effective at minimizing external failure and incentivizing internal detection.

CHAPTER 3

CONSUMER PERCEPTIONS OF PRODUCT RECALL STRATEGIES: THE EFFECT OF ATTRIBUTION ON REPURCHASE INTENT, RECALL SATISFACTION, AND RECALL RESPONSIBILITY

3.1 INTRODUCTION

This research explores how firm statements about the operational and supply chain characteristics of product failure influence consumer perceptions and repurchase intent when a product is recalled. A product recall is the publically announced removal from the market of a product due to quality issues which constitute a potential safety hazard to consumers, particularly if the quality issue constitutes a violation of applicable product safety laws (CPSC, 2012a; FDA, 2011b; FSIS, 2012; 2012; NHSTA, 2006). Our study, a vignette-based experiment, focuses on the context of recalled food products regulated by the FDA, which regulates approximately 80% of the food products in the US, representing an estimated 75% of consumer expenditures on food (Institute of Medicine and National Research Council of the National Academies, 2010). Essay 2 investigates FDA-regulated food recalls from the perspective of the consumer, aiming to answer the following research question: *how does information provided regarding operational and supply chain management aspects of quality failure affect consumer perceptions and repurchase intent when a product is recalled?*

While the operations and supply chain management literature has not specifically addressed the consumer side of product recalls, the marketing, communications and crisis management literature suggests that firms that respond earlier and unambiguously take

responsibility for product failures, when appropriate, will minimize reputational and market share effects (Dawar & Pillutla, 2000; Laufer & Coombs, 2006; Pearson & Clair, 1998; Smith, Thomas, and Quelch, 1998).

The marketing literature has also established that consumers make spontaneous evaluations of responsibility when products fail to meet their expectations; however, this literature has not specifically addressed perceptions of the operational or supply chain related information provided during a product recall (Folkes, 1984). In other words, while the literature has, to some degree, evaluated how consumers respond to product performance and quality issues and, in turn, how those responses relate to behavioral intentions, we know very little about how consumers interpret information during a product recall about the cause of a defect and the possible prevention of a future recurrence. Consequently, the literature does not, with regard to recall communication, indicate if it is preferable to communicate directly and candidly about the circumstances of the product failure or to communicate only such information as is required by law.

Product recalls are conducted, in part, to reduce the level of consumer exposure to potentially harmful products (Packman, 1998). Product harm issues occur when a product does not perform according to accepted safety standards. For consumer products (e.g., electronics, toys, sporting equipment, furniture, and appliances), unsafe products are associated with 32,000 deaths and 35 million injuries annually in the US and have been demonstrated to impose costs in excess of $900 billion on the public (CPSC, 2012b). Product recalls can impact short-term demand across entire market segments (Chu et al., 2005; Crafton et al., 1981; Marsh et al., 2004; Reilly & Hoffer, 1983;

Thomsen et al., 2006), negatively influence share prices (Hoffer et al., 1988; Jarrell & Peltzman, 1985; Rhee & Haunschild, 2006; Thirumalai & Sinha, 2011; Thomsen & McKenzie, 2001), damage brand equity and influence consumer behavior with respect to repurchase intent (Cleeren, Dekimpe, & Helsen, 2008; Siomkos & Kurzbard, 1994). In some cases, they also impact firm survival (Chen et al., 2009).

Recalls of all types of products have received attention from the media, policy-makers, and industry, in part due to a recent upward trend in the total number of recalls occurring in the US and due to the tremendous costs which defective, and potentially hazardous, products impose on consumers, firms, and society as a whole (Bapuji, 2011; FDA 2011b; Nestle, 2003; Institute of Medicine and the National Research Council of the National Academy, 2010). This attention has been reflected by the academic community; however, to date, the linkage between consumer perceptions of operational and supply chain aspects of quality failures and indicators of future purchase behavior has not explicitly been studied.

The initial public communication of a product recall is typically handled via a recall announcement constructed by the firm conducting the recall. While some of the information included in these announcements is prescribed by regulation or agency guidance, firms have the freedom to provide discretionary information which can shape consumer impressions of the recall event. For example, when the Peanut Corporation of America (PCA) recall of various peanut-based products cascaded throughout the US food supply chain in 2009 and 2010, it affected firms that had used PCA products as ingredients. These affected firms then conducted their own product recalls, often citing

the cause of the recall as contamination introduced by a supplier (Wittenberger & Dohlman, 2010).

We propose that this type of statement is a form of impression management used by firms when accounting for negative events publically (Bansal & Clelland, 2004; Folkes, 1988a). We use *attribution theory* to explain how consumers react to specific aspects of operational and supply chain information provided in product recall announcements. Attribution theory has been used extensively to explain how individuals ascribe causation to everyday events, particularly when the events are perceived to be important, unusual, and disconfirm a prior expectation (Folkes, 1988; Weiner, 2000). In other words, this research focuses on *what firms communicate* about the failures that cause product recalls and, in turn, *how consumers react*.

Our investigation is tied to the operations and supply chain management field in two ways: first, details of defects, including where and how they occur and how they will be prevented in the future, are supply chain attributes. Second, only those firms with the requisite operational capabilities will have the opportunity to choose to disclose discretionary information in the event of a product recall. To the extent that consumers respond to information provided by the firm, their future behavior regarding the purchase of the same or similar products and brands may be influenced (Folkes, 1984; 1988ab; Folkes & Kotsos, 1986; Siomkos & Kurzbad, 1991; Weiner, 2000).

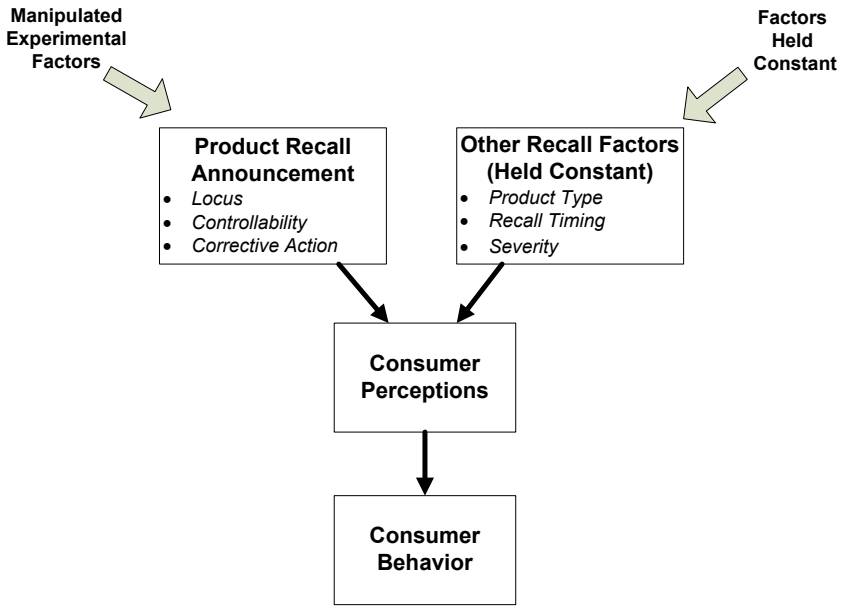
This study advances the understanding of consumer behavior relative to operational and supply chain information under product recall conditions, which is important for two reasons. First, firms conducting recalls need concrete evidence of how consumers react

to these events; such reactions are difficult, if not impossible, to measure during actual product recall events. Indirect recall costs, which include reduced market share and reputational effects, are difficult to measure and believed to be significantly greater than the more easily measureable direct costs, such as warranty, litigation, product replacement and reverse logistics (Jarrell & Peltzman, 1985; Rupp, 2003). As such, we argue that studying consumer perceptions and behavior in response to product recalls is of particular importance. If, in fact, managing consumer impressions through specific types of communication can minimize negative market share effects, firms not only have incentives to potentially be more transparent in their recall announcements, but to also develop the necessary capabilities so that the relevant causal information is available at the time of the recall announcement.

Second, policy-makers need to better understand consumer reactions to recall announcements under a variety of conditions. Such understanding is critical to the design and implementation of effective regulations, particularly with respect to aligning firm incentives for reducing external quality failures and conducting product recalls responsibly.

Figure 3.1 depicts a framework of factors which influence the consumer perceptions of product recalls, ultimately resulting in behavioral outcomes. In our behavioral experiment, we manipulate the factors of locus, controllability, and corrective action (defined in Section 3.2) in product recall announcements, holding other factors, such as product type, recall timing and recall severity, constant.

Figure 3.1 Conceptual Framework: Product Recall Announcements and Consumer Behavior



3.1.1 A Behavioral Framework of Consumer Perceptions of Product Recalls

We posit that consumer behavior is influenced by the perceptions of the recall event. Consumer reactions to a product recall are expected to include assessments of responsibility for the recall (e.g., *recall responsibility*) and an orientation towards future purchases of the same product (e.g., *repurchase intent*). In addition to the notions of recall responsibility and repurchase intent, we add the concept of *recall satisfaction* to indicate the consumer's level of satisfaction with the recalling firm's handling of the recall event.

Other consumer behaviors, which may be influenced in this framework, include complaining behavior or negative word-of-mouth (Folkes, 1984), temporary withdrawal from purchases of products similar to that recalled (Bougie et al., 2003; Zeelenberg & Peters, 2007), in addition to whether the consumer responds to the recall by checking for the recalled product in their home and, if found, whether the consumer ignores the warning and consumes the product, discards the product, or seeks a refund for the product (Hallman et al., 2009). Our study focuses on *perceived recall responsibility*, *repurchase intent*, and *recall satisfaction*, specifically on the effects of manipulating communication of *locus* (internal to or external to the firm conducting the recall), *controllability* (under the volitional control of the firm conducting the recall or its supply) and *corrective action* (a corrective action for the defect is given or withheld) on these dependent variables.

We develop theoretical constructs and operational definitions, tentatively validate measures, and then conduct a pilot study using a fractionated factorial experimental design with a single food product type. Our experiment uses vignettes based on actual firm announcements of product recalls to collect responses from a sample of students and non-student participants. We use our pilot data (179 subjects) to construct measurement models for multi-item dependent and covariate scales and then test our hypotheses using multivariate analysis of covariance (MANCOVA).

In this exploratory study, we find support for effects of locus, controllability and corrective action on recall satisfaction and responsibility, consistent with the directions indicated by attribution theory. In other words, when a firm explains that a supplier was the source of a contamination, on average; consumers are more satisfied with the

handling of the recall and attribute responsibility to the supplier more so than the manufacturer. Uncontrollable causes, which might be believed to be more excusable that controllable causes, are associated with higher levels of repurchase intent and recall satisfaction. Corrective actions are, as expected, associated with higher levels of recall satisfaction. While these initial findings are intriguing, we propose further modifications to the measures and scenarios and suggest future applications of this experiment with an expanded design in a more demographically heterogeneous sample.

The rest of this paper is organized as follows. In Section 3.2 we provide background on product recalls, and more specifically, food product recalls, and then develop a hypothesized model of how the content of firm communication lead to consumer perceptions and behavior based on attribution theory. We then develop our hypotheses based on the proposed conceptual model (Section 3.3). We explain our research design (Section 3.4), including the preliminary development of scenarios and measures, and a process of measurement validation, which concludes with the collection of the pilot data. Next, we analyze the pilot data using latent variable methods to validate measurement models and MANCOVA to test our theoretically-based hypotheses (Section 3.5). Finally, we discuss our results and implications and propose further measurement modifications for the future deployment of this study (Section 3.6).

3.2 CONCEPTUAL DEVELOPMENT

3.2.1 Product Recall Announcements

When a product is recalled, firms construct a response which includes communicating with regulatory agencies, informing the public and managing returns, replacements,

repairs or refunds. Typically, the first official public indication of that response is a product recall announcement which, in the US, is usually issued by the firm conducting the recall under the guidance of the regulating agency, such as the Consumer Product Safety Commission (toys, electronics, sporting goods and other consumer products), the FSIS (meat, poultry and egg products), the National Highway and Traffic Safety Administration (automobiles) or the FDA (food products including in-shell eggs, dairy, fruits, vegetables, and seafood and pharmaceuticals, cosmetics and medical devices).

Regardless of the product type or agency involved, product recall announcements share common features, including descriptions of the products affected, the nature of the defect and the hazard, where the product was sold, contact information for the firm conducting the recall, and instructions for handling the recalled product. Other types of information, specifically where (locus), how and why (indicating controllability) the defect occurred and any information regarding corrective actions (stability) intended to prevent future occurrence of the same defect are suggested by agency guidance, but not required. This study focused on the effectiveness and outcomes of providing discretionary operational and supply chain information about the nature of the product quality issue, specifically in the context of food product recalls regulated by the FDA.

3.2.2 Attribution Theory

Attribution theory, originally developed by Heider (1958), has been used to explain how consumers make causal inferences when experiencing life events, products and services (Heider, 1958; Folkes, 1988ab). The underlying premise of this theory is this: although individuals' attribution of causality is not without error or bias, the process is

relatively logical, and, ultimately, affects future behavior (Folkes, 1988). Furthermore, the dimensions of attribution theory have been found to have particularly high predictive validity when the situation involves unexpected and negative outcomes, which matches the product recall context (Coombs, 2007).

Attribution theory has been studied relative to self-perception, motivation (Kelley, 1972; Weiner & Kukla, 1970), and in the marketing literature, perceptions of product quality failures or product harm events (Folkes, 1984; Klein & Dawar, 2004). We adapt this theory to operationalize the three dimensions of causal attributions with respect to operational and supply chain characteristics of product quality failures. Table 3.1 describes how each of the three dimensions of attribution theory corresponds to our operational definitions in the operations management and supply chain context. We suggest that communications by the firm are subsequently *interpreted* by the audience receiving the message. In this case, it is the consumer receiving the message (Coombs & Holladay, 1996). Attribution theory predicts that consumer causal attributions regarding product quality issues would fall along three dimensions: *locus, controllability*, and *stability* (Folkes, 1984; Weiner, 2000). We adapt the theory to the context of the operational and supply chain aspects of the defect, defining *locus* as *internal* or *external*, *corresponding to defects that occur inside or outside the boundaries of the operations of the firm conducting the recall* (Klein & Dawar, 2004).

Following prior use of attribution theory, *controllable causes* exist when the firm conducting the recall, or its supplier, has a higher degree of volitional control over the cause of the defect. *Uncontrollable causes* reflect an inability to influence the occurrence

of a defect, based on the procedures and policies in place at the time the defect occurred. As an example, if a pathogen is detected by a food producer in their raw materials or finished goods and the test result is not reported or acted upon, the defect is characterized as controllable. In other words, the firm had the necessary information to prevent the defect from passing on to the consumer, but failed to do so. Alternatively, a temporary refrigeration failure not detected by the food producer prior to the product being distributed, but which causes a quality problem that results in a recall, would be considered an uncontrollable cause.

It could be argued that the producer has the *responsibility* to monitor their operations more closely, and therefore, *should* have detected the refrigeration failure. Nevertheless, from the perspective of attribution theory, this type of failure is considered *uncontrollable*, while the deliberate non-reporting of a defective quality test result is *controllable*. Controllable/uncontrollable defects, as such, occur along a continuum from deliberate contamination by the producing firm to events that a producer has little to no control over, such as the unanticipated quality impacts of a natural disaster.

Finally, the causal attribution dimension of *stability* is mapped to our construct of *corrective action*. Stable causes are those that consumers can reasonably expect to happen again in the future (Dawar & Klein, 2004; Folkes, 1984; Weiner, 2000); consequently, firms that provide information in the recall announcement describing corrective actions which will minimize the likelihood of recurrence of the same defect are signaling that the cause is *unstable*. We propose that corrective action is a proxy for one dimension of stability, acknowledging that other aspects of stability may be salient,

including firm reputation, compliance and product recall history and other past actions. Table 3A.1 provides operational definitions for all of the constructs used in our study (See Appendix 3A).

Table 3.1 Causal Attribution Dimensions and Operations Management/Supply Chain Management Operational Definitions

Attribution Dimension	Operational Definition
Locus	INTERNAL LOCUS occurs when a defect that causes a product recall occurs INSIDE the manufacturing firm. In other words, the defect is because of something that happened within the manufacturer's operations. EXTERNAL LOCUS occurs when a defect that causes a product recall occurs OUTSIDE the manufacturing firm. In other words, the defect is because of something that happened at a supplier or retailer, or some other entity other than the manufacturer.
Controllability	CONTROLLABILITY is the degree to which the occurrence of the defect is under the volitional control of the firm conducting the recall or their supplier. Consequently, a defect that is more highly UNCONTROLLABLE would be one which would be unanticipated and difficult to detect.
Corrective Action/Stability	A STABLE DEFECT is a product defect that the consumer could reasonably expect to occur again in the future. STABLE DEFECTS are indicated by a lack of communication regarding any potential CORRECTIVE ACTION which would minimize the risk of recurrence of that particular defect in the future. An UNSTABLE DEFECT is a product defect that the consumer could reasonably expect NOT TO OCCUR in the future. UNSTABLE DEFECTS are indicated communication regarding potential CORRECTIVE ACTION which would minimize the risk of recurrence of that particular defect in the future.

3.2.2.1 Product Recall Announcements and Supply Chain Capabilities

When product recalls are announced, firms have the opportunity and often choose to include types of information not required by regulation. For example, during the pet food recalls, which occurred due to melamine contamination (Roth et al., 2008ab), and the recalls which occurred due to the use of salmonella-contaminated peanut products from the Peanut Corporation of America, suppliers were identified as the source of the defect when the individual firms announced the recalls. In making these statements, firms may attempt to deflect blame from their own processes, which is one way to defend against customer backlash due to product harm.

Blame deflection is only possible if the firm has relevant and reliable information (i.e., where the failure occurred, the nature of the failure and possible future prevention) on hand at the time the recall is announced. Such information, even if available, takes time to confirm and configure into an appropriate statement which satisfies agency requirements, internal stakeholders (e.g., legal counsel) and external stakeholders (e.g., suppliers, distributors and retailers). In this way, we argue that operational competencies, derived from monitoring systems, supply chain design, and relationships with channel partners, have a direct bearing on the type of impression management options available to a firm conducting a recall.

Similar to providing information about the locus of a defect, firms may provide information about the level of volitional control associated with the cause of the defect. A controllable cause may be relatively straightforward to explain in terms of preventing future occurrences, for example, by explaining the corrective actions which the firm will

take to remedy the defect's cause. Conversely, an uncontrollable cause may not be as amenable to a corrective action, but may be better tolerated by the consumer. Communicating a corrective action, regardless of the underlying nature of the defect's cause, may be undertaken to signal the firm's intentions to correct the situation that allowed the defect to occur. By communicating the unstable nature of the cause (i.e., it is unlikely to reoccur), firms can reassure consumers of their good intentions, in addition to influencing the consumer's perception of the risk of the product.

As with locus, we argue that the firm's ability to communicate information about controllability and corrective actions is limited by the competence of the firm conducting the recall and its supply chain partners relative to rapidly communicating, investigating the underlying cause of the defect, and developing a suitable remedy. Given the short time frame available to firms when constructing a recall announcement (once a defect is confirmed), we suggest that only firms with superior capabilities in these dimensions will have the option to manage consumer impressions along all three attribution dimensions.

By investigating the effect of these dimensions on consumer perceptions and behavioral intentions, we aim to offer firms a prescription which 1) distinguishes when higher levels of transparency may be preferred, 2) links the development of the supply chain competencies with the opportunity to manage risk in the event of a product recall, and 3) suggests what type of policy interventions might be necessary to align firm incentives with the desired action. To this end, we argue that the current regulatory systems may allow firms to inappropriately deflect blame (e.g., to suppliers) and that the required content of a product recall announcement could influence firm actions to prevent

recalls (i.e., because the information required in the recall announcement will impact consumer impressions negatively) and impose consequences via the recall announcement (i.e., because required information provides consumers with a clearer picture of the nature of the failure).

Before offering our hypotheses which address the relationships between attributions and consumer perceptions and behavioral intentions, we fully develop our conceptual basis for our dependent variables: perceived recall responsibility, perceived recall satisfaction, and repurchase intent.

3.3 MODEL DEVELOPMENT

3.3.1 Perceptions of Recall Responsibility

Attributions have been linked to the assessment of blame or responsibility in multiple contexts; forming a judgment about accountability for a situation is a precursor to forming an intention to change behavior (Shaver, 1985; Weiner, 1995). We propose that perceived *recall responsibility, defined as the degree to which the consumer holds the supplier, or the firm, conducting the recall responsible for the recall event*, is a key dependent variable, because making justifications regarding the underlying cause of the defect is intended, in part, to diffuse responsibility (Laufer, 2002; Laufer et al., 2005).

The crisis management literature, in particular, has focused on attributions which lead to the assignment of responsibility, since higher levels of responsibility are related to negative reputational effects, in this context (Bülow-Moller, 2010; Coombs, 2004; Coombs & Holladay, 2002). To return to the example of the hundreds of recalls related to the Peanut Corporation of America salmonella contamination, many of those recalls

included a statement explaining that the supplier was the source of the contamination. In some cases, the supplier was named.

We distinguish three separate types of responsibility assignment which correspond, respectively, to the degree of responsibility attributed by the consumer to 1) the supplier, 2) the manufacturer, and 3) being shared by both the supplier and the manufacturer. We find this to be appropriate to our research context, because our extensive review of food recalls indicates that recall announcements commonly include information which cue attributions of responsibility to either the manufacturer or an upstream supplier. Because the manufacturer (e.g., the purchasing organization) is the producer of the finished good in our context, we include the concept of shared responsibility to capture the idea that recall responsibility resides within supply chain partners, to some degree, when the defect originates with the supplier.

3.3.2 Perceived Recall Satisfaction

Recall announcements are a medium which conveys multiple types of information, including the affected product specifications, the nature of the hazard, details about the defect and its cause, and remedies (e.g., refund, repair, replacement). Based on consumer preferences for specific types of information, and analogous to the construct of purchase satisfaction (Zeelenberg & Pieters, 2004), we propose that *recall satisfaction is defined as the degree to which the consumer's expectations regarding the handling of a product recall are met by the firm announcing the recall*.

Studies investigating consumer response to recall announcements with respect to risk reduction have found that consumers have definite preferences for the amount and type of

information provided regarding a recall (Hallman et al., 2009). Among the types of information considered "very important", consumers included hazard information, any confirmed illnesses, a description of the affected product, what to do with the affected product, what is being done to fix the problem which caused the recall, and how the defect occurred. Of these types of information, the latter two (what is being done to fix the problem and how the defect occurred) are recommended; however, they are not required for inclusion in the announcement. The preceding items are required and appear in every press release announcing a food recall.

Purchase satisfaction has been studied extensively as a predictor of repurchase intent and brand loyalty (Oliver, 1993; Oliver & DeSarbo, 1988; Oliver & Swan, 1989; Westbrook & Oliver, 1991; Zeelenberg & Pieters, 2004). The commonly used definition is phrased in terms of expectation confirmation or disconfirmation: purchase satisfaction occurs to the degree that a consumer's expectations regarding a product are met or exceeded (Oliver, 1993). Analogously, we argue that recall satisfaction is an important dependent variable in our research context, because it is an indicator of consumer's perceptions of the adequacy of firm response and remedies.

3.3.3 Repurchase Intent

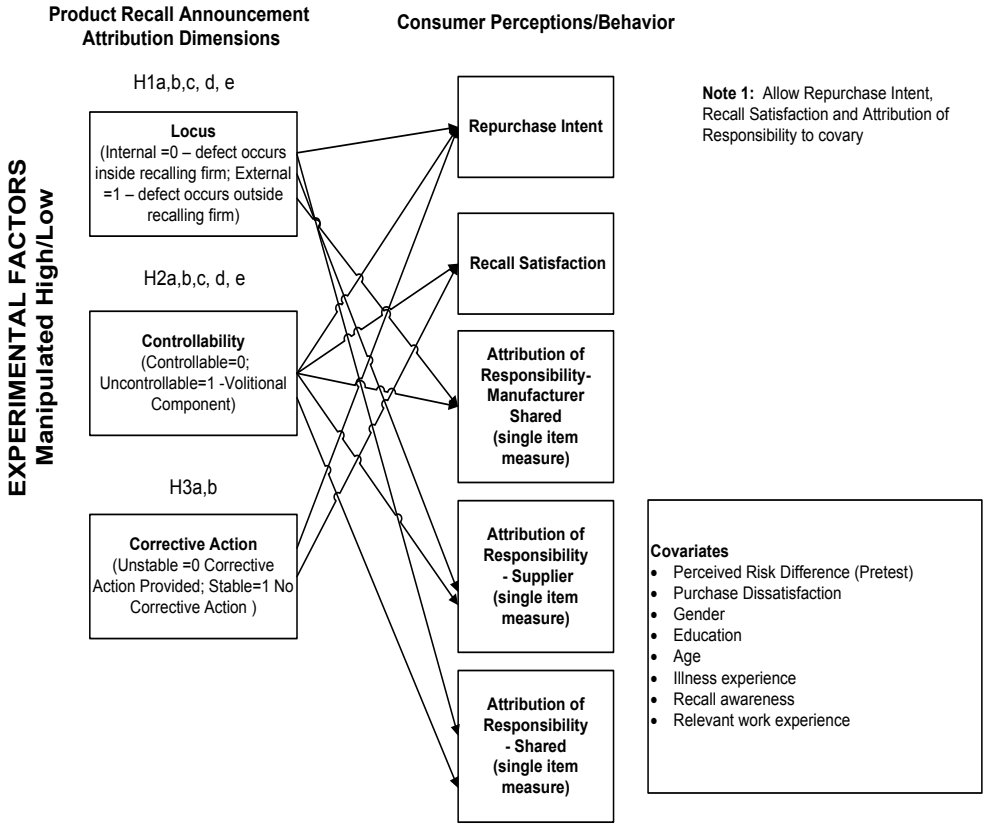
Repurchase intent, *defined as a consumer's intent regarding the future purchase of a product that they have already purchased at some time in the past*, has long been studied as an outcome variable, particularly in the marketing literature. In studies specific to consumer reactions to product harm and recall events, repurchase intent has been linked to corporate social responsibility statements, brand equity (Dawar & Pillutla, 2000; Klein

& Dawar, 2004), and perceived risk (de Matos & Rossi, 2006; Siomkos & Kurzbard, 1994). In the product harm context, repurchase intent has not been hypothesized as a direct outcome of consumer's causal attributions, in part due to the mediating influence of purchase satisfaction (dissatisfaction) theorized, and has been demonstrated to account for significant variance in repurchase intent in more general consumer contexts (Anderson & Mittal, 2000; Mittal & Kamakura, 2001). Nevertheless, due to the prevalence of studies examining the demand impacts of product recalls, both for the recalling brand and for other brands (Chu et al., 2005; Crafton et al., 1981; Marsh et al., 2004; Reilly & Hoffer, 1983; Thomsen et al., 2006), we argue that it is important to consider the potential direct effects of attributions on repurchase intent.

3.3.4 Effects of Causal Attributions

We hypothesize that locus and controllability have direct effects on each of our dependent variables: perceived recall responsibility (e.g., supplier, manufacturer, and shared responsibility), recall satisfaction and repurchase intent. Our construct of corrective action, which maps to attribution theory's stability dimension, is hypothesized to have a direct effect on recall satisfaction and repurchase intent. This exploratory study is limited by the use of a fractionated factorial experimental; main effects and interaction effects are aliased with each other and therefore cannot be separately tested. The logic and theoretical basis for the hypothesized main effects are developed in the following sections. Figure 3.2 depicts the hypothesized relationships tested in this exploratory study.

Figure 3.2 Hypothesized Model



3.3.4.1 Locus

Locus is operationalized in our study, consistent with the literature, as *internal* (corresponding to defects that originate within the recalling firm's organization) or *external* (corresponding to defects that originate within a supplier's organization). In our review of food product recalls, we observed that where such information is applicable, firms tend to include information regarding a supplier's role in contributing to a defect that results in a recall. This type of impression management would seem to attempt to

shift blame for a recall and any resulting negative consequences, such as injury or illness, away from the firm conducting the recall.

Consistent with attribution theory, we hypothesize that, as blame is focused away from the firm conducting the recall (external locus), both the repurchase intent for the recalled item and recall satisfaction will be higher, as compared with the recalls with an internal locus (Shaver, 1985; Weiner, 2000).. Thus, a reduction in actual repurchase intent would be represented by a positive coefficient (e.g., towards a higher agreement with statements that indicate that the recall has negatively affected intentions to repurchase). This wording is consistent with prior work in the product harm context (Siomkos & Kurzbard, 1994).

Similarly, we hypothesize that external representations of locus would have the effect of increasing recall satisfaction, holding other factors constant, because consumers will approve of the recalling firm's handling of the situation more when blame is shifted externally. Recall satisfaction is operationalized as the degree to which the consumer's expectations regarding the handling of a product recall are met by the firm conducting the recall. Higher levels of recall satisfaction are associated with higher levels of agreement with our measurement items. In other words, repurchase intent and recall satisfaction will be more *favorable* for external locus causes than for internal locus causes.

More formally, these two hypotheses are stated as follows:

HYPOTHESIS 1a ***External locus*** *is associated with higher levels of* ***repurchase intent*** *as compared to internal locus causes.*

HYPOTHESIS 1b ***External locus*** *is associated with higher levels of* ***recall satisfaction*** *as compared to internal locus causes.*

When the recall announcement describes the source of a defect as external to the recalling firm (i.e., in our context, the defect source is the supplier), the announcement provides a cue to the consumer that responsibility is associated, at least in part, with an entity other than the firm conducting the recall. As such, we hypothesize that external locus will be associated with higher levels of supplier responsibility and lower levels of manufacturing responsibility. Furthermore, while we hypothesize that consumers will shift the attribution of responsibility towards the supplier, in these situations, the firm conducting the recall (e.g., the purchasing firm, in this instance) will be perceived as sharing accountability for the defect with the supplier. If supported, the implication of this hypothesis is that while describing the supplier as the source of a defect has the effect of shifting some responsibility away from the purchasing firm, it does not absolve the purchasing firm completely. Consistent with this logic, we hypothesize that:

HYPOTHESIS 1c *External locus causes is associated with lower levels of perceived manufacturer responsibility, as compared with internal locus causes.*

HYPOTHESIS 1d *External locus causes is associated higher levels of perceived supplier responsibility as compared with internal locus causes.*

HYPOTHESIS 1e *External locus is associated higher levels of perceived shared responsibility as compared with internal locus causes.*

3.3.4.2 Controllability

Controllability captures the volitional role of entities involved in causation. *A controllable defect is one in which the supplier or manufacturer has volitional control over the circumstances* that *allowed the defect to happen or pass on to the consumer.* For

example, in a study which explores consumer reactions to product failure using attribution theory, the example is given of a weight loss supplement which does not perform as expected (e.g., the consumer does not lose weight when using it). A failure scenario controlled by the consumer included not following the diet prescribed to accompany the weight loss supplement. Conversely, a failure scenario not controllable by the consumer was related to an illness which required a prescription medication which interfered with the active ingredient in the weight loss supplement. The consumer, in this instance, was unaware that the medication would interfere with the supplement (Folkes, 1984). The key difference between these two situations, with respect to attribution theory, is the consumer's volition with respect to the failure. By not following the recommended diet, even while aware of the potential adverse effect on the weight loss program, the consumer has exercised volition which affects the outcome. In the case of the illness, which required a prescription medication, there is an absence of volition due to the illness and the consumer's lack of awareness of the potential for the prescription to affect the outcome (Folkes, 1984). In an experiment based on similar scenarios, and a survey-based study, Folkes (1984) linked controllability to anger responses related to product failure.

We argue that controllability of the underlying cause of a defect which causes a product recall will influence consumer perceptions for how the recall is being handled (recall satisfaction), assessments of responsibility for the recall, and repurchase intent. In our operationalization of controllability, we distinguish between causes under the complete volitional control of either the recalling firm or their supplier (i.e., a quality test

result is ignored by the recalling firm or their supplier), as compared with less volitional causes (i.e., a lightning strike causes a power failure which leads to loss of refrigeration and contributes to contamination, but the loss of refrigeration goes undetected). While we might argue that all manufacturing circumstances are, to some extent, under the supervision, and consequently, control, of the recalling firm or their supplier, the scenarios which include the undetected loss of refrigeration are comparatively less controllable (i.e., being due to an extreme event, such as a lightning strike, and undetected, indicating, since it was unknown, that the failure was not a result of deliberate or volitional action). As a result, we expect consumer perceptions of these failures to differ, based on the idea that controllable failures, to some degree, demonstrate a willful neglect of potential adverse effects for consumers. Therefore, we would expect consumers to, on average, respond negatively, with correspondingly lower levels of repurchase intent and recall satisfaction. In other words, repurchase intent and recall satisfaction will be more *favorable* for uncontrollable causes than for controllable causes. More formally, these hypotheses are stated as follows:

HYPOTHESIS 2a *Controllability is associated with reduced repurchase intent.*

HYPOTHESIS 2b *Controllability is associated with reduced recall satisfaction.*

Because controllability is understood to incorporate volition, it follows that an individual or organization that has control over an outcome or situation can also be held accountable. We argue that this provides the rationale for a direct linkage between controllability and perceived responsibility in our research context. Assignment of responsibility is a key feature of attribution theory, since determining a responsible party

reduces the uncertainty associated with a negative situation (Weiner, 1995). As a result, we hypothesize that consumers seeking to reduce the uncertainty regarding the safety of a specific product – and food products, in general – will have a strong need to assign responsibility, and that cues as to the controllability of the defect will increase attributions of responsibility to entities involved in the recall. We expect to observe the effects of controllability on each of our perceived responsibility constructs, resulting in higher levels of responsibility attributed to manufacturers and suppliers individually, and higher levels of shared responsibility when the defect is controllable. These hypotheses are stated as follows:

HYPOTHESIS 2c *Controllability is positively associated with perceived manufacturer responsibility.*

HYPOTHESIS 2d *Controllability is positively associated with perceived supplier responsibility.*

HYPOTHESIS 2e *Controllability is positively associated with perceived shared responsibility*

3.3.4.3 Corrective Action (Stability)

Stability relates to the permanence of the cause of the defect (Folkes, 1984). A *stable* defect is one that a consumer could reasonably expect to occur again in the future. An *unstable defect* is one that the consumer can reasonably expect will not occur again in the future (Folkes, 1994). *Stability is called* ***corrective action*** *and is operationalized by providing (unstable) or withholding (stable) information regarding a corrective action.* Typically, quality management systems include procedures for investigating the underlying cause of failures, including environmental, health and safety and quality failures. Once a root cause is determined, the organization can determine what type of

remedy, or corrective action, to put in place to minimize the risk of the same problem occurring in the future.

The FDA requires that firms report corrective actions to the agency as part of the process of closing out a product recall event (FDA, 2009a). While FDA guidance suggests that product recall announcements include information regarding corrective actions, such information is not required by regulation. In our review of food product recall announcements, we find that less than 2% of recall announcements provide any information regarding the investigation of root cause or corrective action. We speculate that firms may be reluctant to provide corrective action information due to liability concerns (i.e., describing the corrective action implies what could have been done to prevent the defect in the first place, which could contribute to liability) or, simply, that due to the pressure of needing to announce a recall quickly after a defect is detected, firms do not have the time to adequately determine the appropriate corrective action (Packman, 1998).

Prior research has indicated that, in a product recall context, consumers consider information related to how a quality problem will be remedied to prevent recurrence "very important" (Hallman et al., 2009). Attribution theory would predict that unstable causes (i.e., those causes for which a corrective action is stated in the recall announcement) create less concern for consumers with respect to repurchase intent, in part because the danger, or risk, associated with the product would be considered smaller, because the probability of recurrence is lower than that of a stable defect cause. Furthermore, by providing a cue that the cause is unstable, the recalling firm can convey

a sense of urgency in remedying the problem and influence consumer perceptions that the recall is being managed appropriately. We, therefore, hypothesize that omitting information regarding a corrective action has a negative effect on repurchase intent and recall satisfaction; in effect, when recall announcements contain information regarding a proposed corrective action, consumers have more positive perceptions of recall handling (recall satisfaction) and higher levels of repurchase intent. *In other words,* ***repurchase intent*** *and* ***recall satisfaction*** *will be less favorable when* ***no corrective action*** *is communicated than for when a corrective action is communicated.*

More formally, we propose the following:

HYPOTHESIS 3a *Corrective action communications are associated with higher levels of repurchase intent.*

HYPOTHESIS 3b *Corrective action communications are associated with higher levels of recall satisfaction.*

3.3.4.4 Covariates

Consistent with other studies that evaluate consumer perceptions of a product harm issue, we include a number of covariates (Dawar & Pillutla, 2000; de Matos & Rossi, 2006; Jolly & Mowen, 1985; Klein & Dawar, 2004; Mowen, 1980; Mowen, Jolly & Nickell, 1981; Siomkos & Kurzbard, 1991). The purpose of the covariates is to parcel out the variance in our dependent variables that is related to the plausible control variables, rather than the hypothesized relationships of interest. We control for perceived purchase risk, purchase dissatisfaction, several demographic covariates, including gender, age and education level, and several experience-related variables (e.g., relevant work

experience, recall awareness, and illness experience). The following sections describe the nature and purpose of the covariates in more detail.

3.3.4.4.1 Perceived Purchase Risk

Perceived purchase risk is the consumer's assessment of potential adverse consequences associated with a purchasing goal (Cox & Rich, 1964; Bettman, 1973; 1979; Dowling & Staelin, 1994). Increasing the probability and severity of adverse consequences increases the perceived risk. In evaluating risk, consumers consider various types of loss which could result from the purchase decision, including poor product performance, loss of social status, physical loss, financial loss, time, psychological losses and frustration (Taylor, 1974). Higher levels of perceived risk with respect to a purchasing decision lead to a variety of risk-reduction behaviors among consumers, including extensive searching behaviors, evaluation of larger amounts and more varied types of information, and product trials (Dowling & Staelin, 1994; Gemunden, 1985).

We adopt perceived risk as a subjective assessment of risk from the consumer's perspective, rather than an objective measure of risk (Bauer, 1960; Mitchell, 1999). *Perceived risk is defined as consisting of two components: some level of probabilistic belief about the likelihood of a negative outcome and a belief regarding the level of consequences (loss or harm) associated with a negative outcome* (Cunningham, 1967; Kogan & Wallach, 1964; Mitchell, 1999).

Because one component of perceived risk includes an assessment of the probability of a negative consequence, we expect that providing evidence of a negative consequence

will increase perceived risk, regardless of any attributional manipulations (Bettman, 1973; 1979; Taylor, 1974; Dowling & Staelin, 1994; Mitchell, 1999). Our study is specifically designed to offer evidence of potential physical loss by revealing the potential hazard associated with the product under recall. We control for the level of perceived purchase risk present prior to the experimental treatment to parcel out variance that is due to individual level differences in the baseline perceptions of risk.

3.3.4.4.2 Perceived Purchase Dissatisfaction

Purchase satisfaction occurs to the degree that a consumer's expectations regarding a product are met or exceeded (Oliver, 1993). This concept can be extended to encompass dissatisfaction and incorporating negative expectation disconfirmation. Dissatisfaction has been linked to evaluations of product quality; we expect that by manipulating the experimental scenario to indicate poor product quality, and specifically a potentially hazardous product, that significant levels of purchase dissatisfaction will result. This is consistent with the notion that a food product recalled due to a safety issue does not meet the most basic expectations for quality. *We operationally define purchase dissatisfaction as occurring when a consumer's expectations about a product's performance are not met* (Oliver, 1993; Oliver & DeSarbo, 1988; Oliver & Swan, 1989; Westbrook & Oliver, 1991).

The relationship between purchase dissatisfaction and repurchase intent has been demonstrated to be stronger than that of satisfaction and repurchase intent (Anderson & Mittal, 2000). We consequently argue that controlling for the effects of purchase dissatisfaction on our dependent variables is appropriate and necessary.

3.3.4.4.3 Demographics, Recall Awareness and Relevant Experiences

Individual level characteristics may influence satisfaction levels, assignment of responsibility and repurchase intent (Mittal & Kamakura, 2001). Therefore, we control for gender, age and level of education. The prevalence of food recalls over the past few years may have altered individual perceptions of food recalls, in general. Consequently, we control for recent personal experiences with foodborne illness (perceived) and the awareness of recalls occurring within the past year. Because subjects with work experience in areas related to food (food service or food manufacturing) or healthcare may have specialized knowledge that influences their perceptions of food recalls, we control for the presences of these types of experiences.

3.4 RESEARCH DESIGN

We use a 2^3 experimental design (two levels each for locus, controllability and corrective action) with a random assignment to test our hypothesized model (Table 2.2). Randomization of the treatment assignment minimizes the possibility that effects are due to a form of selection bias. For this exploratory study, we use a fractionated factorial design, consisting of four treatment combinations. This design allows us to test the effects of locus, controllability, and corrective action on our dependent variables. Table 3.2 depicts the treatment combinations and coding scheme used for the experiment.

Table 3.2 Treatment Combinations & Coding

Scenario Number	Locus	Control	Corrective Action
1	External – High = 1	Controllable – Low =0	Corrective Action – Low = 0
2	Internal – Low = 0	Uncontrollable – High =1	Corrective Action – Low = 0
3	Internal – Low = 0	Controllable – Low =0	No Corrective Action – High = 1
4	External – High =1	Uncontrollable – High =1	No Corrective Action – High = 1

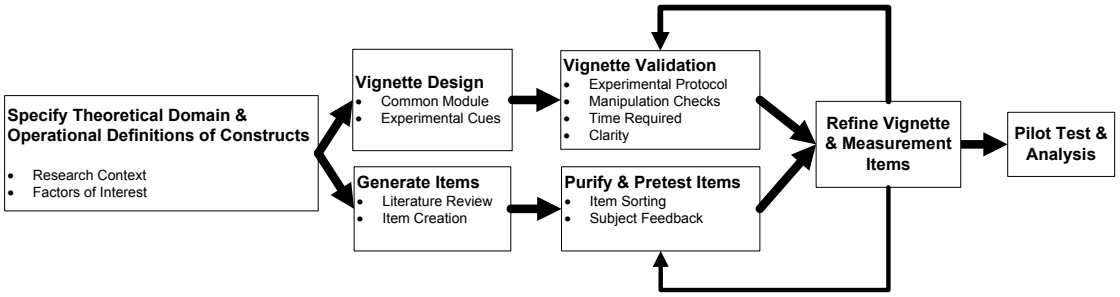
3.4.1 Vignettes and Measures

Our experiment is administered as a framed field experiment which consists of exposing participants to a written scenario, or vignette, to provide the stimulus for the treatment (Rungtusanatham, Wallin & Eckerd, 2011). A vignette-based experiment is appropriate for several reasons. First, it is not possible to cause a product recall to measure consumer reactions, nor is it possible to pre-test consumer perceptions prior to a product recall. Second, vignettes have been successfully used in the marketing literature to test various hypotheses regarding brands and product harm events, as well as in the operations management literature (Gürhan-Canli & Batra, 2004; Jolly & Mowen, 1985; Mowen et al., 1981; Rungtusanatham et al., 2011; Tsiros & Mittal, 2004). The vignettes describe a purchase scenario followed by the discovery that the purchased item has been recalled. Pre-test items were administered after a brief set of experimental instructions, followed by the purchase and recall scenario, post-test items and manipulation checks.

To ensure appropriate measurement validity and reliability, we developed measurement items and the experimental vignettes following an iterative process that combines elements of recommended scale development practices (Churchill, 1979; Roth,

Schroeder, Huang, & Kristal, 2007) and an experimental vignette design (Hall, 2012; Rungtusanatham et al., 2011). The combined measurement development process is depicted in Figure 3.3.

Figure 3.3 Vignette and Measurement Development (Adapted from Roth, et al., 2007 and Rungtusanatham et al., 2011)



After reviewing the literature to develop our research context and factors of interest, we developed a set of tentative constructs and operational definitions. Our literature review included relevant government regulations, guidance, and reports from the Government Accountability Office, which studies recall systems, and the content and format of all press releases issued for food product recalls from 2008 through 2010, in addition to marketing, operations and supply chain management literature. Our measurement and vignette development process consisted of the following steps: 1) a pen and paper exercise using a preliminary vignette and open ended questions in an MBA class; 2) item sorting exercises; 3) vignette pre-testing to assess clarity, readability, time required to complete the exercise and comprehension of the manipulation checks; and 4)

final measurement item and vignette refinement prior to administering the experiment to a pilot group of student and non-student participants.

3.4.2 Vignette Development

3.4.2.1 Pen & Paper Exercise – MBA Students

A pen and paper pilot exercise was conducted with 15 MBA students as a preliminary assessment of vignettes and measurement items. This exercise provided confirmation of the realism of the vignette and a sense of the amount of time subjects would need to complete this type of exercise, in addition to providing preliminary feedback on the effectiveness of the manipulations. Appendix 3B contains the four sets of vignettes and questions used in the pen and paper exercise. We also noted that the participants: 1) in general, attributed responsibility to the manufacturer or supplier consistent with the manipulation of locus, 2) responded to the use of the word "voluntary" in the recall announcement as a positive statement regarding the firm's handling of the recall, 3) responded to the product recall announcement with reduced repurchase intentions and 4) had stated preferences about what type of information they were interested in seeing in a recall announcement consistent with prior studies (Hallman et al., 2009). As a result of this exercise, we chose to exclude the word "voluntary" from our vignettes, since nearly all food recalls are considered voluntary (i.e., "voluntary" in terms of FDA recall announcements simply means that the recall is being conducted by the firm and not as part of a formal enforcement action by the FDA) and the concept does not convey substantive information about the responsiveness of the firm conducting the recall. See Appendix 3B for additional details regarding this exercise and its results.

3.4.2.2 Common Module

As recommended by Rungtusanatham et al. (2011), we built our vignettes after determining the factors of interest for manipulation and the general format of the vignette around a common module. The common module consisted of the format of the vignette (instructions, introductory statement, press release, and follow-up statement) and all aspects of the vignette held constant over all treatments. The type of defect (salmonella), description of symptoms and possible outcomes of illness, number of illnesses (121 illnesses), product type (frozen cheese pizza), product description (batch numbers, packaging, distribution area) and the name of the recalling firm, were the same throughout all four scenarios. In addition, each scenario contained the same introductory paragraph setting up the vignette and the same follow-up paragraph concluding the vignette. The format of the press release was taken from actual FDA press releases and consistent with FDA guidance regarding required information and standard hazard language. The warning regarding the symptoms and possible outcomes of salmonella, for example, was taken exactly from FDA guidance.

3.4.2.3 Experimental Cues

After developing the common module, we developed tentative experimental cues for our manipulated factors: locus, controllability and corrective action (stability). We pre-tested a version of the vignette with cues for an external locus, controllable failure with a corrective action included. We selected this version for pre-testing, because it represents the extreme case for our three factors, and since we were interested in determining

whether participants would comprehend the scenario, as intended (Hall, Roth & Rungtusanatham, 2012).

Pre-testing was conducted by deploying the vignette and a set of follow-up questions to a group of undergraduate students at Clemson University. Students received extra credit for completion of the exercise, which was deployed by on-line survey. Questions asked as part of the exercise included comprehension checks (e.g., "a number of people were made ill by this product"), intended to assess whether or not participants understood the scenario as intended, potential measurement items for perceived responsibility and recall satisfaction, opportunities for free text responses to comment on the clarity of wording, and a question which asked participants to estimate the amount of time spent on the exercise. Responses were recorded on a five point agreement scale with a sixth choice included for "don't know". The full text and results of the pre-testing exercise are included in Appendix 3B.

The results of the vignette pre-test are reported in Appendix 3B. The pre-test results indicate that the overall comprehension of the preliminary vignette was high for salient aspects of the scenario, including the type of defect, defect severity, illnesses associated with the product, supplier involvement (locus), controllability and corrective actions. In addition to this pre-test, the measurement item sorting exercises, discussed in the next section, included a variety of items intended to act as experimental cues for the high and low levels of each attribution dimension. The results of the item sorting guided the writing of the manipulation check items and the final vignette design. Sorting results for these cues/manipulation check items are included in the measurement items sorting

procedure. In finalizing the vignettes, we made a few changes: the supplier involved in the external locus vignettes is domestic, rather than foreign, and the vignettes were simplified slightly to concentrate the cues, as shown in Table 3.3 , which illustrates the final experimental cues for each of the four scenarios used in the pilot study.

Table 3.3 Vignettes & Treatments Cues

Scenario	Locus	Control	Corrective Action
Scenario 1 – External, Controllable, Corrective Action	"The source of the contamination was cheese supplied by Robert's Dairies, Inc."	"The cheese had failed internal quality tests conducted by Robert's Dairies, Inc. prior to sale to Chef Milo."	"Chef Milo has instituted additional internal and independent third party testing of incoming raw materials."
Scenario 2 – Internal, Uncontrollable, Corrective Action	"Interrupted power supply to refrigeration units at Chef Milo's manufacturing facility, causing products to be exposed to higher temperatures, leading to contamination with salmonella."	"The refrigeration failure was not detected by the Chef Milo Corporation prior to distributing the frozen pizzas."	"Chef Milo has instituted new procedures and retrained employees to require more frequent inspections of refrigerated operations."
Scenario 3 – Internal, Controllable, No Corrective Action	"The source of the salmonella contamination was the processing equipment at the Chef Milo facility"	"Pizzas were distributed to retailers after multiple units had failed internal quality tests conducted by Chef Milo prior to distributing the product."	No corrective action information provided
Scenario 4 – External, Uncontrollable, No Corrective Action	"Interrupted power supply to refrigeration units at Robert's Dairies manufacturing facility, causing products to be exposed to higher temperatures, leading to contamination with salmonella."	Neither the Chef Milo Corporation, nor Robert's Dairies, Inc., were aware of the refrigeration failure when the frozen pizza was distributed."	No corrective action information provided

3.4.3 Measurement Item Development

From the literature we developed a tentative set of 15 items representing 3 constructs and 18 experimental cues representing the three dimensions of attribution at the high and low levels of each dimension. Perceived purchase dissatisfaction (Oliver, 1993; Oliver & DeSarbo, 1988; Oliver & Swan, 1989; Westbrook & Oliver, 1991), perceived purchase risk (Mitchell, 1999; Siomokos & Kurzbad, 1994), and repurchase intent (Siomokos & Kurzbad, 1994) have been studied extensively. Consequently, the proposed scales only reflected slight modifications to our context. We conducted an item matching exercise using an online survey tool which also provided respondents with an opportunity to provide open-ended responses regarding the clarity of the items. To maintain a reasonable number of items for each sort, we split the constructs into three groups, sorting the most similar constructs together. In addition to sorting the proposed measurement items, we included items representative of treatment cues for the three dimensions of attribution theory. The purpose of these exercises was to establish preliminary content, convergent and discriminant validity, and tentative reliability (Roth et al., 2007). See Appendix 3B for the complete lists of items included in each of the three sorting exercises.

The degree of agreement in item sorting was assessed to establish tentative validity and reliability. Moore & Benbasat's (1991) item placement ratio calculates the proportion of judges that selected the targeted construct (i.e., a "hit") and the total number of potential item placements. This ratio can be used to provide a measure of the proportion of judges selecting the target constructs and, by examining "off-diagonal"

placements, provides information about the potential discriminant validity issues (Menor & Roth, 2009). For the three different sorts, the overall hit ratios ranged from 51.79% (stable/unstable) to 82.3% (repurchase intent, internal locus, external locus, purchase dissatisfaction). We anticipated that participants would have some difficulty in distinguishing controllable causes versus uncontrollable causes, and consequently, were seeking cues which provided the most separation between these two concepts. Similarly, stable/unstable was difficult to match, in part, due to the nature of the experimental cue: stable was related to defects for which no corrective action was proposed.

The results of sorting manipulation check items with their intended experimental cue definition were further confirmed by the vignette pre-test. Individual measurement scale hit ratios (e.g., repurchase intent, perceived purchase risk and purchase dissatisfaction) exceeded the 75% recommended cutoff (Roth et al., 2007). See Appendix 3B for detailed reporting of item placement ratios.

Collectively, the literature review and sorting exercises provide tentative support for the reliability and validity of the constructs and the measurement items. The results of these exercises were used to further refine the measurement items. In addition, between the sorting exercises and the pilot study, we added two constructs: recall satisfaction (i.e., patterned after purchase satisfaction, as discussed previously) and perceived recall responsibility (i.e., single item measures of manufacturer, supplier and shared responsibility). These constructs, and the associated items, were not part of the sorting process conducted prior to the pilot study. The final measurement items are included in Appendix 3B.

3.4.4 Implementation

3.4.4.1 Sample Frame and Experimental Procedure

The sample frame for this experiment includes consumers of convenience food products living in the US. The experiment was administered through an online survey which randomized the assignment of treatments across four scenarios. Undergraduate and MBA classes were solicited in-class, where possible, to increase participation. A combination of in-class cash prizes and on-line gift certificates were used as incentives for participation. In-class incentives were offered at the rate of $20 per 10 participants with awards made based on a random lottery. On-line incentives were offered in the amount of $100 gift certificate randomly awarded at the end of the exercise. The Facebook solicitation of participants used an on-line drawing of a gift certificate as an incentive. Of the valid responses, frequency of the administration of each of the four scenarios was roughly equivalent (see Appendix 3A for details).

3.4.4.2 Subjects

Our sample consists of university students recruited from classes offered in the College of Business and Behavioral Sciences at Clemson University and a convenience sample of non-student adult participants solicited via Facebook. A total of 210 responses were collected over a period of fourteen days. The original sample of 210 cases was reduced to 180 cases by listwise deletion when one or more predictors, covariates or dependent variable measures were missing.

Approximately 65% of the useable sample was male; 35% was female. Over 97% of the sample had at least "some college" education. Over two-thirds (68.5%) of the sample

was employed, at least part-time, and averaged six to ten years of work experience. More than three-quarters (78.8%) of the sample consisted of undergraduate or graduate students. While upper age groups are not well-represented in this convenience sample, 40.6% of the sample was aged 30 or older. Complete demographic details of the sample are included in Appendix 3A.

3.4.4.3 Sample Description

Table 3.4 describes the variable minimum, maximum, mean and standard deviations.

Table 3.4 Sample Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
Purchase Risk (Pre-Test)	2.00	7.00	4.79	0.93
Purchase Dissatisfaction	3.33	7.00	5.58	1.00
Repurchase Intent (Higher values indicate lower repurchase intent)	2.00	7.00	5.41	1.10
Recall Satisfaction	1.00	7.00	4.42	1.09
Manufacturer Responsibility	1.00	7.00	5.32	1.10
Supplier Responsibility	1.00	7.00	4.77	1.37
Shared Responsibility	1.00	7.00	4.60	1.44
Gender (1=Male)	.00	1.00	0.65	0.48
Age	1.00	6.00	2.59	1.07
Education	2.00	7.00	4.08	1.27
Illness Experience	1.00	7.00	4.22	1.97
Recall Awareness	1.00	7.00	5.34	1.64
Food Service Work Experience (1=yes)	.00	1.00	0.54	0.50
Food Manufacturing Work Experience (1=yes)	.00	1.00	0.06	0.23
Healthcare Work Experience (1=yes)	.00	1.00	0.17	0.37

Note: See Appendix 3B, Tables 3B.8 and 3B.10 for item wording.

3.4.4.4 Covariates

A pre-test question assessed the applicability of the vignette with the participant's purchasing behaviors (How frequently do you buy frozen pizzas? ; 7 point scale ranging from "never" to "nearly always"). About 13.9% of the sample responded "never" with the balance of the sample reporting "infrequently" to "very often". Approximately 60.5% of the sample reported buying frozen pizzas "occasionally," "sometimes," "often," or "very often". On the basis of these self-reported purchasing behaviors, we conclude that the product featured in our vignettes is relevant to the participants and that the participants can be considered as having sufficient knowledge of the product to participate and provide meaningful responses. Over three-quarters (75.86%) of participants recalled hearing about at least one food recall within the past year and over half (52.8%) reported believing that they may have become ill from consumption of a food item within the past year. Both of these awareness scales were collected from the post-test, and therefore, could be inflated due to the treatment. Over half (52.8%) of participants reported having work experience in the food service area, 5.6% reported having experience in food manufacturing and 16.7% reported having experience in healthcare.

3.4.4.5 Manipulation Checks

Manipulation checks were administered as part of the post-test and were intended to measure whether the participants comprehended the intended differences in the treatment levels for locus, controllability and corrective action. Multiple manipulation check questions were included for each manipulated factor, in part to improve the robustness of

our manipulation checks, and in part, because we were concerned with the participants' ability to recognize differences between defects and actions associated with the supplier versus the manufacturer. A complete list of manipulation check items is included in Appendix 3B.

We evaluated the manipulation checks for each treatment, comparing the responses for each item with the level of the treatment received. One-way ANOVA indicates that we achieved the desired level of treatment comprehension for the locus for three of the four manipulation checks ($p<.01$). One of the four manipulation check questions ("The salmonella contamination in the pizza came from the cheese supplied by Robert's Dairies Inc.") was not statistically different in the internal or external locus comparison. We attribute this to measurement issues highlighted in our debriefing interviews with participants.

The manipulation check for controllability indicates that we achieved acceptable or marginally acceptable treatment comprehension for three of the four manipulation checks ($p<.0001$, $p<.085$ and $p<.123$, see Appendix 3B for details). As noted in our measurement development, we expected to have some difficulty in achieving discriminant validity for the controllability construct; nevertheless, the manipulation check results support cautious interpretation of our experimental results for controllability. One-way ANOVA of the manipulation of stability provides evidence of directionally appropriate and statistically significant differences ($p<.0001$ for all three items). In total, we conclude that our manipulation checks are supportive of the internal

validity of our experiment; however, we will seek to improve the manipulation of controllability in the final study.

3.4.4.6 Realism

Realism was measured with two seven point agreement scales ranging from "very strongly disagree" (1) to "very strongly agree" (7): "The situation described in this exercise was realistic," (mean=5.850, standard deviation=.906) and "I took my role in this exercise seriously," (mean=6.256, standard deviation =.694). Based on these results, we conclude that the experimental scenario was sufficiently realistic.

3.5 RESULTS

Our analysis consists of a validation of the measurement models for two sets of scales: the dependent variables repurchase intent and recall satisfaction (Measurement Model 1) and the covariate scales purchase dissatisfaction and perceived risk (Measurement Model 2). After demonstrating the reliability and validity of these scales, we use aggregated mean values for these scales, in addition to our other measures, in a MANCOVA model which tests for the primary effects of the three manipulated attribution dimensions, controlling for our covariates.

3.5.1 Confirmatory Analysis of Measurement Models

The final items for the four multi-item scales were used in the pilot study; the pilot sample has been analyzed to refine and confirm the measurement models for the two scaled dependent variables and two scaled covariates. Roth et al. (2007) recommends that measurement models be evaluated to confirm validity and reliability in the second stage of measurement development. The data used to validate these scales was collected

using seven point Likert scales anchored with "very strongly disagree" and "very strongly agree".

3.5.1.1 Reliability Analysis

We conducted a confirmatory factor analysis (CFA) to evaluate the composite reliability of the four multi-item scales. In our assessment of these scales, we found that one item (RP5) in the repurchase intent scale did not adequately fit with the remaining items, or the construct definition, since it was more closely related to withdrawing from an entire category of purchases, rather than repurchase intent for the specific product being recalled. This change reduced the repurchase intent scale from five to four items, but remains consistent with our definition, and consequently, ensures content validity. The Werts-Linn-Joreskog composite reliabilities for the four scales are reported in Table 3.6; because each reliability is equal to, or exceeds, the .70 cutoff values, we have support for acceptable scale reliability (Bollen, 1989).

Table 3.5 Measurement Scale Descriptives and Composite Reliability

Construct	Min	Max	Mean	Items	Standard Deviation	Reliability[1]
Purchase Risk (Pre-Test)	2	7	4.79	4	0.93	0.70
Purchase Dissatisfaction	3.33	7	5.58	3	1.00	0.88
Repurchase Intent	2	7	5.41	4	1.10	0.90
Recall Satisfaction	1	7	4.42	3	1.09	0.81

3.5.1.2 Unidimensionality Analysis

Our CFA results provide evidence of unidimensionality based on goodness-of-fit indices. We use Joreskog-Sorbom's goodness-of-fit (GFI) and adjusted goodness-of-fit (AGFI), the Bentler-Bonnett normed fit index (NFI) and non-normed fit index (NNFI), in addition to the comparative fit index (CFI), to substantiate the unidimensionality of our scales. For the goodness of fit indices, a value of 1 indicates a perfect fit and values exceeding .90 are considered substantive evidence of unidimensionality. In addition, we report root mean-square residuals (RMR) and root mean-square errors of approximation (RMSEA) for both models; values approaching zero are desirable, however, a value of .06 is considered to indicate a good fit and .08 is a moderate fit (Bollen, 1989). Table 3.7 provides the fit index values for the two measurement models compared with the standard evaluation criteria.

Table 3.6 Measurement Models 1 & 2 Fit Statistics

	Model 1 **Repurchase Intent & Recall Satisfaction**	**Model 2** **Perceived Risk and Purchase Dissatisfaction**	**Criterion**
Model χ^2	49.52 (13 d.f.) p<.000001	20.02 (13 d.f.) p<.09	Not significant
GFI	0.92	0.97	0.90
AGFI	0.84	0.94	0.90
CFI	0.96	0.98	0.90
NFI	0.94	0.95	0.90
NNFI	0.93	0.97	0.90
RMR	0.08	0.07	0.06
RMSEA	0.13	0.06	0.06

3.5.1.3 Convergent Validity Analysis

We evaluate convergent validity by reviewing the magnitude and direction (sign) of the standardized path loadings of each item onto the designated construct. Standardized path loadings occur in the direction expected and are statistically different from zero ($p<.01$). Table 3.8 reports the standardized path loadings, critical ratios and p-values for each item. The average variance extracted (AVE) is calculated for each scale; a value of .50 or greater is considered evidence of convergent validity (Bollen, 1989). The perceived purchase risk scale has a marginal AVE value of .40; we conclude that this is acceptable for the exploratory nature of this study, but it will need to be addressed in a future implementation of this experiment. Based on path loadings and average variance extracted, we conclude that the measurement scales adequately reflect the designated constructs and exhibit convergent validity.

Table 3.7 Measurement Models: Standardized Path Loadings, Critical Ratios and Average Variance Extracted

Construct	Indicator Label	Measurement Item	Standardized Path Loading	Critical Ratio
Measurement Model 1				
		Average Variance Extracted = .71		
Repurchase Intent	RP1	This product recall has decreased the chance that I would buy a Chef Milo pizza in the future.	0.92	-
	RP2	I would be less likely to purchase the Chef Milo brand in the future.	0.86	17.29
	RP3	I would buy a different brand of pizza next time.	0.78	13.98
	RP4	I would avoid purchasing the Chef Milo brand in the future.	0.89	18.51
		Average Variance Extracted = .59		
Recall Satisfaction	RSat1	I feel satisfied with Chef Milo Corporation's statements about quality.	0.83	11.14
	RSat2	I'm satisfied with how the Chef Milo Corporation handled this product recall.	0.74	10.16
	RSat3	The Chef Milo Corporation seems to have handled this problem responsibly.	0.85	-
Measurement Model 2				
		Average Variance Extracted = .40		
Purchase Risk (Pre-Test)	PR1	I'm concerned about food safety.	0.77	4.88
	PR2	I'm worried about the quality of the food I consume.	0.77	-
	PR3	I could get sick from eating food that has quality issues.	0.41	8.68
	PR4	I feel like consuming frozen cheese pizza could be hazardous.	0.47	8.68
		Average Variance Extracted = .71		
Purchase Dissatisfaction	DIS1	I am unsatisfied with the quality of this product.	0.82	6.31
	DIS2	I feel dissatisfied with my purchase of this product.	0.79	6.95
	DIS3	This product did not meet my expectations for quality.	0.87	-

1. The critical ratio (CR) for a one-tailed test of significance and the associated p-values are: CR=1.64, p<.05; CR=2.33, p<.01; CR=3.10, p<.0001.
2. The items presented here were measured on a scale from 1 "very strongly disagree" to 7 "very strongly agree".
3. Average variance extracted (AVE) >.50 indicates convergent validity.

3.5.1.4 Discriminant Validity Analysis

Discriminant validity is assessed by conducting a X^2 difference test for each pair of scales. This procedure includes a CFA, in which the paired constructs are allowed to freely correlate, and a CFA, in which the correlation between the constructs is constrained to equal one. A significant X^2 difference result provides evidence that the constructs are different, and consequently, supports discriminant validity. Table 3.9 reports the results of the X^2 difference tests, indicating that, because the p-values for each test are less than or equal to .05, we have support for discriminant validity

Table 3.8 Pairwise Tests of Discriminant Validity

Construct Scale Pairs	Unconstrained		Constrained		χ^2 difference
	χ2	d.f.	χ2	d.f.	test p value
Purchase Risk					
Purchase Dissatisfaction	49.52	13	154.35	14	0.001
Repurchase Intent					
Recall Satisfaction	20.02	13	46.70	14	0.001

3.5.1 Hypothesized Model Analysis

The data was analyzed using a 2^3 between-subjects multivariate analysis of covariance (MANCOVA) to allow for relationships between the dependent variables (recall satisfaction, responsibility and repurchase intent) and to test for the effects of the three dimensions of attribution (locus, controllability and stability/corrective action) while controlling for the covariates. Data screening was conducted by first examining the distribution of the dependent variables for deviations from normality. Skew and kurtosis

were mild for all of the dependent variables (largest skew = -.620; largest kurtosis = 1.272). The assumption of linearity between the dependent variables was checked by creating scatterplots of each dependent variable combination and examining the plots for signs of non-linearity. No obvious non-linearity was detected. MANCOVA assumes independence of observations. Based on the way the experiment was administered using a random assignment of scenarios, via an online survey, or individually, in a classroom setting or via an emailed link, we have no expectation that this assumption will be violated. Multivariate normality was tested by examining outliers based on Mahalanobis' distance within each treatment group. One outlier was detected above the critical value (Critical value= 24.322 α=.001 for 7 variables). This case (X^2 =25.125) was located within Scenario 2 and was deleted, resulting in a final sample of 179 cases. Equality of covariance was evaluated using the very conservative Box's M test (F=1.81; d.f. 45, 72,517; p<.001), which indicates a violation of this assumption. However, our results should be robust to this violation, because of the ratio of cases to the number of variables and the nearly equivalent number of subjects in each treatment group (Tabachnik & Fidell, 2007).

Levene's test was used to evaluate equality of error variance; results indicate a violation of this assumption for repurchase intent, recall satisfaction, supplier responsibility, and shared responsibility. Manufacturing responsibility did not violate this assumption. F statistics and Pillai-Bartlett Trace statistics are robust to this violation when treatment group sizes are nearly equal (Tabachnik & Fidell, 2007).

3.5.2.1 Multivariate Tests of Significance

Multivariate tests indicate that locus, control, stability, age, education, recall awareness (having heard about a food recall within the past year), purchase dissatisfaction, and gender are significant predictors of at least one of the dependent variables. Power to detect effects is greater than .8 for locus, stability, and purchase dissatisfaction, indicating adequate power. Power is between .6 and .76 for control, education, recall awareness, perceived risk, and gender, indicating moderate power to detect effects. Tests of between subject effects (corrected model) indicate the overall model is significant for each of the dependent variables (repurchase intent: $F=10.87$; d.f. 13,165; $p<.0001$; recall satisfaction: $F=3.45$; d.f. 13,165; $p<.0001$; supplier responsibility: $F=3.11$; d.f. 13,165; $p<.0001$; manufacturer responsibility: $F=5.38$; d.f. 13,165; $p<.0001$; shared responsibility: $F=3.78$; d.f. 13,165; $p<.0001$).

3.5.2.2 Covariates

Applying the adjusted $\alpha=.01$ criterion for the univariate F tests, we find the following significant covariate effects: 1) recall awareness affects shared responsibility ($F=9.10$; d.f. 1, 178; $p<.003$) positively, 2) food manufacturing work experience has a nearly significant positive effect on repurchase intent ($F=5.38$; d.f. 1, 178; $p<.022$), and 3) purchase dissatisfaction negatively affects repurchase intent ($F=77.61$; d.f. 1, 178; $p<.0001$), supplier responsibility ($F=10.03$; d.f. 1, 178; $p<.002$) and manufacturer responsibility ($F=13.57$; d.f. 1, 178; $p<.0001$). Note that repurchase intent and purchase dissatisfaction are negatively worded scales (i.e., “I would buy a different brand of pizza next time” and “I feel dissatisfied with my purchase of this product” are rated on a 7

point agreement scale where lower scores indicate higher repurchase intent/lower dissatisfaction and higher scores indicate lower repurchase intent/higher dissatisfaction). Perceived risk (pre-test level) is marginally significant in its negative effect on repurchase intent ($F=5.93$ $p<.016$).

3.5.2.3 Hypothesis Tests

Specific hypotheses were tested with planned contrasts, univariate F tests and Roy-Bargmann step-down analysis. Table 3.9 summarizes the results of the univariate F tests, and step-down analysis. Table 3.10 illustrates each set of hypotheses and summarizes the evidence associated with each hypotheses test result.

Table 3.9 MANCOVA Summary Results: Univariate and Stepdown Tests of Effects of Locus, Controllability and Corrective Action

Manipulated Factor	Dependent Variable	Univariate F	d.f.	Univariate α^1	Stepdown F	d.f.	α
Locus	**Repurchase Intent**	3.83	1, 175	0.052	4.17	1, 175	0.052
	Recall Satisfaction	**7.86****	1, 175	0.006	**5.12****	1, 174	0.022
	Manufacturer Responsibility	**20.04****	1, 175	0.0001	**12.14****	1, 173	0.0001
	Supplier Responsibility	**10.87****	1, 175	0.001	**20.4****	1, 172	0.001
	Shared Responsibility	**29.92****	1, 175	0.0001	**26.34****	1, 171	0.0001
Controllability	**Repurchase Intent**	**13.34****	1, 175	0.0001	**14.56****	1, 175	0.0001
	Recall Satisfaction	**6.70****	1, 175	0.01	2.33	1, 174	0.12
	Manufacturer Responsibility	**8.10****	1, 175	0.005	2.31	1, 173	0.12
	Supplier Responsibility	1.60	1, 175	0.21	0.62	1, 172	0.55
	Shared Responsibility	0.95	1, 175	0.33	0.80	1, 171	0.48
Corrective Action	**Repurchase Intent**	3.46	1, 175	0.06	3.78	1, 175	0.06
	Recall Satisfaction	**6.18****	1, 175	0.0001	**12.37****	1, 174	0.0001
	Manufacturer Responsibility	**8.09****	1, 175	0.005	2.69	1, 173	0.091
	Supplier Responsibility	0.41	1, 175	0.525	1.04	1, 172	0.439
	Shared Responsibility	0.49	1, 175	0.487	0.002	1, 171	0.968

** $p<.05$

Table 3.10 Hypothesis Testing Results Summary

Hypothesis	Hypothesis Statement	Results
H1a	**External locus** has a direct negative effect on **repurchase intent** as compared with the **internal locus (**Lower values of repurchase intent scale correspond to higher levels of repurchase intent).	**H1a not supported.**
H1b	**External Locus** has a direct positive effect **recall satisfaction** as compared with the **internal locus.**	**H1b supported** (Contrast Difference = .367; p<.02).
H2a	**Uncontrollable causes** have a direct and negative effect on **repurchase intent** as compared with the **controllable causes** (Lower values of repurchase intent scale correspond to higher levels of repurchase intent).	**H2a supported (**Contrast Difference =-.294 p<.027). However,repurchase intent and recall satisfaction are correlated at -.357, so the variance explained may not be unique.
H2b	**Uncontrollable causes** have a direct and positive effect on **recall satisfaction** as compared with the **controllable causes.**	**H2b supported** (Contrast Difference =.383 p<.016). However, repurchase intent and recall satisfaction are correlated at -.357, so the variance explained may not be unique).
H3a	**Corrective action** has a direct negative effect on **repurchase intent** as compared with the **no corrective action** (Lower values of repurchase intent scale correspond to higher levels of repurchase intent).	**H3a not supported.**
H3b	**Corrective action** has a direct negative effect on recall satisfaction as compared with **no corrective action**.	**H3b supported (**Contrast Difference = -.570 p<.0001).

Hypothesis	Hypothesis Statement	Results
H1c, H1d, H1e	**Locus** has a direct effect on **attribution of responsibility**. More specifically, external locus will be associated with lower levels of **manufacturer responsibility**, higher levels of **supplier responsibility** and higher levels of **shared responsibility,** as compared with the internal locus.	**H1c, d and e supported.** Manufacturer responsibility contrast difference=.715 p<.001 and shared responsibility contrast difference=-.608 p<.0001. However shared responsibility has a within cell pooled correlation with recall satisfaction of .166, so variance explained may not be unique. External locus of control is associated with lower levels of manufacturer responsibility (Contrast difference=1.043, p<.0001). However manufacturer responsibility has a within cell pooled correlation of -.246 with recall satisfaction, therefore variance explained may not be unique.
H2c, H2d, H2e	**Controllability** has a direct effect on **attribution of responsibility**. More specifically, controllable causes will be associated with higher levels of **manufacturer responsibility**, higher levels of **supplier responsibility** and higher levels of **shared responsibility** as compared with the uncontrollable causes.	**H2c supported (**Contrast difference=-.326 p<.032; however pooled within cell correlation between recall satisfaction and manufacturer responsibility = -.246, consequently, variance explained may not be unique). **H2d and e not supported.**

3.5.2.4 Assessment of Dependent Variables

For the univariate F results, the effective alpha is adjusted by the number of dependent variables (5) to indicate that $p<.01$ could be considered acceptable for an overall $p<.05$ for the group. Univariate F results are reported in Table 3.9.

Roy-Bargmann step-down F tests were conducted to assess the impacts of correlated dependent variables where there is theoretical support for the importance ranking of the dependent variables. For the purposes of our analysis, repurchase intent was considered to be the most theoretically important, based on its implications for sales and market share, followed by recall satisfaction, manufacturer responsibility, supplier responsibility, and shared responsibility. Each step-down test includes dependent variables as covariates, so, for example, the step-down test for recall satisfaction includes repurchase intent as a covariate. The step-down test for manufacturer responsibility includes both recall satisfaction and repurchase intent as covariates, and so on. The step-down tests, in addition to the univariate F tests of effects and pooled within-cell correlations among the dependent variables, is used to assess the unique contribution of a predictor to a specific dependent variable. The interpretation of stepdown F tests are subject to the homogeneity of regression slopes assumption (Tabachnik & Fidell, 2007). This assumption tests for the presence of interactions between manipulated experimental factors and covariates. Homogeneity of regression slopes was supported by F tests which indicated that interactions of the covariates with each of the manipulated factors were not significant at $p<.05$. Stepdown F test results are reported in Table 3.10.

3.6 DISCUSSION

Demographic variables, such as age, gender and education, were not significant predictors of any dependent variable; however, this should be retested in a study with more power, in addition to examining the potential interactions of these variables with other predictors. Illness experience was also not a significant predictor of any dependent variable.

Recall awareness, as measured by whether the subject recalls hearing about a recall within the past year, was significant and positive in its effect on shared responsibility, indicating that the more aware our subjects were of prior recalls, the more likely they were to attribute responsibility to both the manufacturer and the supplier. This result leads us to conclude that the full study should more thoroughly examine the dimensions of recall awareness by developing a multi-item scale.

Purchase dissatisfaction explains a significant amount of variance in repurchase intent, consistent with the literature. Perceived risk is marginally significant. As expected, higher baseline levels of perceived risk are associated with lower levels of repurchase intent. Food manufacturing work experience has a nearly significant positive effect on repurchase intent, indicating perhaps that those who are more knowledgeable about the inner workings and processes of food production are more tolerant of the recall with respect to repurchase intent.

Locus affects recall satisfaction, indicating that when firms communicate that a supplier is responsible for a defect, consumers respond accordingly in the recall satisfaction dimension. However, there is no direct effect supported for the repurchase

intent. Similarly, locus affects the perceived responsibility dependent variables as expected, with the external locus associated with higher levels of supplier responsibility and shared responsibility and lower levels of manufacturer responsibility. The implication of this finding is that the tendency we observed for firms to communicate the involvement of a supplier in a defect that results in a recall may have a positive effect on consumer perceptions of the firm's handling of the recall and the attribution of responsibility for the recall. This finding is an example of how recall announcements may be structured favorably for firms, although this is not necessarily aligned with the objective of protecting consumers from exposure to unnecessary risks. We argue that policy-makers should consider this finding and, at a minimum, ensure that when recall announcements cite a supplier as a cause of a failure that the recalling firm provides additional supporting information to counterbalance what might be a spurious attribution on the part of the consumer. In other words, policy change with respect to the content of recall announcements may be necessary to ensure purchasing firms are held accountable, not only by the regulatory agency, but also by consumers.

Uncontrollable causes are tolerated better with respect to repurchase intent than controllable causes and associated with higher levels of manufacturer responsibility and recall satisfaction. Taken together, these results suggest that, consistent with attribution theory, consumers may expect firms to do more to prevent failures perceived as more controllable than those failures perceived to be uncontrollable. This finding also supports a potential source of leverage if policy-makers pursue regulations that require more specific information to be supplied in the recall announcement, since firms with

controllable causes will arguably be penalized more by consumer perceptions. Alternatively, this finding is a cue to firms of the importance of understanding consumer awareness for, and tolerance of, supply chain failures that may be perceived to be reasonably preventable.

Stability, or the communication of a corrective action to minimize the change the defect could reoccur, was, as expected, associated with higher levels of recall satisfaction, but did not have a significant effect on repurchase intent. No effects were hypothesized between this dimension and perceived responsibility constructs and no significant relationships were found. These results are of interest, in part, because the provision of a corrective action in the recall announcement is extremely rare, occurring in less than 2% of food recalls examined in our Essay 1 study over a three year period. Recalling firms are required to provide some information to the FDA regarding a final planned corrective action prior to the regulatory conclusion of the recall. Therefore, if the "fix" to the problem is simple and something the firm can commit to at the time of the recall announcement, it may be beneficial, in terms of consumer perception, to do so publically. This consideration may be counterbalanced by liability concerns if the public announcement of a corrective action is considered a basis for the admission of culpability (Packman,1998).

The use of MANCOVA provides robust support for effects of attribution dimensions (main effects aliased with interactions) and overall model significance, but does not allow us to test for mediating relationships, which may be present. The estimation of unique contributions to explaining variance in the dependent variables was done using step-down

tests; such results are heavily dependent on assumptions of the relative importance of the dependent variables. Similar to a stepwise regression, these results should be treated with caution due to this underlying assumption which governs which variables become covariates at each level of the step-down test. As noted in Table 3.11, the pooled within-cell correlations of specific dependent variables (e.g., repurchase intent and recall satisfaction) indicates that we cannot claim unique effects. In other words, the significant effects of each factor on each dependent variable (supported by univariate F tests and step-down tests) cannot be considered unique based on this analysis. Nevertheless, contrast results and the pattern of significance in univariate F tests and step-down tests support a cautious interpretation of main effects, as represented in Table 3.10, with the understanding that interactions are aliased with the main effects. The issue of mediating relationships and parceling out unique variance in dependent variables will be resolved in the final study by using structural equation modeling methods.

3.7 CONCLUSIONS

Essay 2 evaluates the effect of manipulating three dimensions of causal attribution (i.e., locus, controllability and corrective action) on consumer perceptions including repurchase intent, recall satisfaction, and perceived recall responsibility while controlling for perceived risk, purchase dissatisfaction and other relevant individual characteristics. We believe the contribution of this study is relevant, particularly since, with increasingly extended supply chains and high proportions of outsourcing, externally-driven product failures are becoming more likely, because the majority of product value-add occurs outside the focal firm.

3.7.1 Contributions

The marketing and crisis communications literature has contributed to our understanding of consumer reactions to product harm and other negative and disruptive events. At the same time, the operations and supply chain management literature has not specifically addressed consumer perceptions of operational failures in the product recall context. It is common for firms, when making product recall announcements, to identify the source of the effects of the recalling firm attributing product failure to a supplier (external locus). This study provides the first evidence that locus operates not only in the "individual-other" context of traditional attribution studies, but also applies when the attribution choice is "other-other". In other words, consumers, on some level, distinguish between supply chain entities and assign responsibility based on the information provided to them.

This study provides preliminary evidence of primary effects of attributional dimensions on important consumer perceptions of product recalls which, based on the literature, will lead to behavior. Consequently, we begin with this work to establish: 1) what firms may be able to do to effectively manage consumer impressions via a recall announcement; and 2) what policy-makers may need to consider when developing regulations regarding announcement content to ensure that firms do not receive undue benefit from impression management and are incentivized to prevent product recalls (i.e., by ensuring that recall announcement information appropriately triggers consumer perceptions that impose consequences on the recalling firm).

Based on food industry trends with respect to the importation of inputs and products and the increased levels of outsourcing to low cost developing countries, we expect firms in this sector will continue to deal with failures that originate outside their internal operations. As a result, when making a product recall, these firms have important choices to make regarding how to communicate the nature of the product quality issues that underlie the recall, including how they convey the source of the product failure and any potential corrective action which will reduce the chance of recurrence.

Based on prior work, we content that these implications are relevant, in part, because indirect costs of product recalls related to consumer behavior are likely to be greater than more tangible, easily measured direct costs, such as repairs, replacements, refunds, reverse logistics and product liability (Jarrell & Pelzman, 1985; Rupp, 2003). Furthermore, for firms to have the option to communicate discretionary information, such as how and why a defect occurred (controllability), and efforts to remedy the problem (corrective action), the recalling firm must have the communication and problem-solving capabilities that enable such information to be reliably available at the time of a product recall. This issue is further complicated by the relatively short amount of time between detecting a failure and making the recall announcement, which limits the recalling firm's opportunity to investigate and verify sources of quality issues.

3.7.2 Limitations and Future Research

The limitations of this study primarily stem from the sample's limited demographic breadth and the use of a fractionated factorial design, which does not allow for separate testing of main and interaction effects of our experimental factors. The full study will

address both of these issues by using a more heterogeneous sample, which will improve the study's power to detect certain relationships (e.g., demographic variables such as age, education and gender) and by using an expanded design to test for interactions between the manipulated factors. While this study was confined to a single product type and failure level, additional levels of failure (severity), product type (pharmaceuticals, and consumer goods.) are of interest. In addition, we would like to improve performance on the manipulation checks, in part by more thoroughly investigating potential combinations of treatment scenarios, in addition to more thoroughly pre-testing manipulation check measurement items. Measurement item performance in pre-testing was marginal to acceptable (See Appendix 3B). Not all measurement items were rigorously pre-tested. Therefore, this step of scale development will be addressed in the final study.

We examine the interface between supply chain management and marketing by making the first direct test of consumer perceptions of supply chain characteristics. This exploratory work takes some initial steps towards explaining *how* short-term demand may be impacted as a result of a product recall, while previous studies have only documented the existence of this effect using event history methodologies (Chu et al., 2005; Crafton et al., 1981; Marsh et al., 2004; Reilly & Hoffer, 1983; Thomsen, Shiptsova, and Hamm, 2006). While firms may attempt to manage consumer attributions by disclosing supplier failures, this is the first study, to our knowledge, to empirically test how consumers interpret this information. Firms increasingly manage complex, lengthy and global supply chains, making the prospect of failures originating outside the firm increasingly likely (Bozarth et al., 2009). Consequently, knowing how informational

content regarding product failure in recall announcements affects how consumers react to product recalls becomes an increasingly important factor to investigate.

CHAPTER 4

CONCLUSIONS

4.1 Study Implications and Contributions

This dissertation contributes to a growing body of literature addressing product recalls, doing so in a relatively unique context (FDA-regulated food products), in addition to using two different perspectives: time to recall and consumer behavior. Although product recalls have received significant attention from the popular press in addition to consumers, policy-makers and researchers, empirical research that characterizes the strategic and operational nature of these failures and factors which influence the relative speed of current industry and regulatory systems to handle the recalls is still extremely limited (Hora et al., 2011; Roth et al., 2008ab).

We address the following two research questions through our theoretically-driven empirical essays: 1) *How do supply chain recall detection competency, in addition to supply chain complexity factors related to time to recall?* 2) *How does information provided regarding operational and supply chain management aspects of product failure affect consumer perceptions and repurchase intent when a product is recalled?*

Essay 1 examines the factors that influence recall timing in a context which has not been studied previously, the FDA-regulated food sector. Time to recall is an important dimension of recall effectiveness, because more timely recalls reduce consumer risks and lessen firm costs, including liability costs and other costs to society. We provide evidence that SCRDC, as measured by the proxy detection entity, is a significant

predictor of time to recall, a finding that can provide implications to practice (e.g., in terms of concentrating efforts and resources on moving detections upstream) and policy (e.g., in terms of motivating regulations and guidance that will improve firm incentives to move detection entity upstream).

This work extends quality management theory by conceptualizing differences in the nature of external failures based on how they are detected (Crosby, 1979; Roth et al., 1992; Juran, 1992). While much of the quality systems improvement work has justifiably focused on reducing the number of external defects by improving internal systems, the increasing length and complexity of supply chains across all product types has led to serious deficiencies in governance and control. As a result, global firms and supply chains have been, and will continue to be, forced to handle product recalls; to the extent that existing quality systems can be extended to encompass the issues that product recalls raise, firms and supply chains may reduce the need for future recalls and, in effect, learn from these disruptions (Haunschild & Rhee, 2006; Thirumalai & Sinha, 2011).

Essay 2 provides insights into whether or not consumers make attributive distinctions between recalling firms and their suppliers when products fail. These insights have implications for both the industry and the regulators. First, when products are recalled, firms face complex choices regarding the communication of the details of the product failure. The literature currently offers mixed messages regarding the importance of early and extensive communication during product harm events. We believe this study offers evidence of how firms should frame communications regarding the product failure and the involvement of the larger supply chain. While the product harm and crisis

communications literature has made substantial contributions in this area (Dawar & Pillutla, 2000; Laufer & Coombs, 2006; Klein & Dawar, 2000; Laufer et al., 2005; Siomkos & Kurzbard, 1994), this is the first study to link the operational and supply chain dimensions of a failure to consumer behavior.

Consequently, this investigation offers tangible evidence of the value of operations and supply chain management capabilities that make information regarding the source, cause and remedy for a failure available quickly enough to communicate it in a recall announcement. Such capabilities require participation and coordination within a firm conducting the recall and also across supply chain partners.

Regulatory agencies (i.e. FDA, USDA) are necessarily concerned with developing regulations and policies that encourage industry to comply and which reduce risk. Essay 2 can guide future policy decisions by offering insights into how consumers respond behaviorally to various stimuli in product recall announcements. To the extent that policy dictates what firms communicate about these important failures, regulators may be able to provide incentives for firms to minimize the risk of product recalls by requiring recall announcement information that materially affects consumer behavior.

Given the limitations of regulatory systems to enforce requirements (e.g., inspections and fines), our findings suggest that the product recall announcement content could be designed in such a way that it: 1) encourages firms to develop the capabilities necessary to provide more complete information at the time of a recall announcement and 2) provides consequences to recalling firms and their suppliers by requiring a higher level of transparency.

4.2 FUTURE RESEARCH

The two essays in this investigation develop a foundation for a larger program of research which we expect to expand to include additional relevant variables in terms of time to recall and recall strategy, and different product type and failure contexts with respect to examining consumer behavior. We plan to extend the use of the database constructed for Essay 1, for example, to examine proxies for SCRDC, and, using an econometric model which adjusts for selection bias, develop a model which predicts the accuracy of recall announcements as another proxy for recall effectiveness.

Furthermore, our research can be the basis for examining underlying issues of incentive misalignment and agency issues between buyers and suppliers managing product quality and product recalls. While Essay 1 is currently limited to examining recall timing in terms of suppliers and the recalling firms as one internal detection entity, we suggest that incentives and governance structures between purchasing organizations and suppliers in the context of quality failures is an area that deserves research attention.

Due to the sensitive nature of the issues addressed by this work, we expect that collecting primary data from firms regarding recall policies and performance may be challenging and could suffer from bias due to social desirability. Furthermore, the use of secondary data, while useful in this context, has limitations (Roth et al., 2009). Therefore, we suggest that there may be avenues of research suggested by this work that will require a more analytical approach to overcome some of the issues with collecting valid empirical data. Information sharing, for example, and incentives between buyers

and suppliers to share unfavorable information regarding defects and quality issues, may be a potential area to explore using analytical models.

In Essay 1, we develop a framework of differences between the nature of failures in perishable and durable products and subsequent differences in recall strategy and management. While Essay 1 only included FDA-regulated food products, a similar strategy for collecting pharmaceutical recall data could be used to compare these two different product categories, and that of medical devices, as a point of comparison for durable products. Similarly, this methodology could be used to compare durable products in other categories (e.g., consumer products, automobiles) to perishable products to begin to more thoroughly assess the differences in product recall strategy and effectiveness in different product categories. Very few studies (see Chu et al., 2005 for an exception) in the product recall literature address more than one product type. This limits the scope and generalizability of the findings and our ability to develop more mature theories of recall strategy. While such work is extremely challenging, due to the need to work across multiple data sources, we contend that it would make a valuable contribution to theory and practice.

The findings from Essay 2 will be used to inform the design and implementation of a full factorial experiment examining food product recalls and consumer attributions. We expect that additional measurements and vignette development will be necessary to ensure robust results. In addition, we plan to access a more demographically broad sample. Beyond the implications of this experiment to the context of product recalls, Essay 2 offers a basis for other future work at the interface between operations and

supply chain management and marketing. Our development of attribution theory's dimension of locus as a construct that applies to different partners in a supply chain opens up additional possibilities for investigating the nature of the consumer perceptions of firm operations and supply chain management practices, including health and safety standards, environmental performance, worker standards, and other corporate social responsibility issues. As lengthy supply chains are opened up to more scrutiny by non-governmental organizations in addition to consumer activists, we anticipate that consumer perceptions of firm operations will increasingly become a matter of practical interest.

CHAPTER 5

REFERENCES

Anderson, E.W., V. Mittal. 2000. Strengthening the Satisfaction-Profit Chain. *Journal of Service Research*. **3**(2) 107-120.

Anderson, P. 2010. How Do Car Recalls Work? Downloaded from: http://www.askmen.com/cars/car_tips_60/93_car_tip.html, on June 22, 2012.

Bansal, P., I. Clelland. 2004. Talking Trash: Legitimacy, Impression Management, and Unsystematic Risk in the Context of the Natural Environment. *Academy of Management Journal* **47**(1) 93-103.

Bapuji, H. 2011. *Not Just China: the Rise of Recalls in the Age of Global Business.* Palgrave Macmillan, New York, New York.

Bapuji, H., P.W. Beamish. 2008. Product Recalls: Avoid Hazardous Design Flaws. *Harvard Business Review* 23-26.

Beamish, P., H. Bapuji. 2008. Toy Recalls and China: Emotion vs. Evidence. *Management and Organization Review* **4**(2) 197-209.

Bettman, J.R. 1973. Perceived Risk and Its Components: A Model and Empirical Test. *Journal of Marketing Research* **10** 184-190.

Bettman, J.R. 1979. *An Information Processing Theory of Consumer Choice.* Addison-Wesley Publishing Company, Reading, Massachusetts.

Bollen, K.A. 1989. *Structural Equations with Latent Variables*. John Wiley & Sons. New York, New York.

Bougie, R., R. Pieters, M. Zeelenberg, 2003. Angry Customers Don't Come Back, They Get Back: The Experience and Behavioral Implications of Anger and Dissatisfaction in Services. *Journal of the Academy of Marketing Science* **31(**4) 377-393.

Bozarth, C., D. Warsing, B. Flynn, E. Flynn. 2009. The Impact of Supply Chain Complexity on Manufacturing Plant Performance. *Journal of Operations Management* **27** 78-93.

Bülow-Moller, A.M. 2010. Corporate Apologia and the Attribution of Guilt. Working Paper, Copenhagen Business School, Denmark.

Buzby, J. C., P.D. Frenzen, B. Rasco. 2001. Product Liability and Microbial Foodborne Illness, *United States Department of Agriculture Economic Report Number 799.*

Buzby, J.C. 2003. International Trade and Food Safety: Economic Theory and Case Studies, *United States Department of Agriculture Economic Report Number 828.*

Cameron, A.C., P.K. Trivedi. 2005. *Microeconometrics Methods and Applications.* Cambridge University Press, New York, New York.

Chen, Y., S. Ganesan, Y. Liu. 2009. Does a Firm's Product-Recall Strategy Affect Its Financial Value? An Examination of Strategic Alternatives During Product-Harm Crises. *Journal of Marketing* **73** 214-226.

Choi, T., D. Krause. 2006. The Supply Base and Its Complexity: Implications for Transaction Costs, Risks, Responsiveness, and Innovation. *Journal of Operations Management* **24**(5) 637-652.

Chu, T., C. Lin, L. Prather. 2005. An Extension of Security Price Reactions Around Product Recall Announcements. *Quarterly Journal of Business & Economics* **44(**3-4) 33-48.

Churchill, G.A. 1979. A Paradigm for Developing Better Measures of Marketing Constructs. *Journal of Marketing Research* **16**(1) 64-73.

Cleves, M., R.G. Gutierrez, W. Gould, Y.V. Marchenko. 2010. *An Introduction to Survival Analysis Using Stata.* Stata Press, College Station, Texas.

Cleeren, K., M. Dekimpe, K. Helsen. 2008. Weathering Product-Harm Crises. *Journal of the Academy of Marketing Science* **36(**2) 262-270.

Cohen, W., D. Levinthal, 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly* **35(**1) 128-152.

Cokins, G. 2006. Measuring the Cost of Quality for Management. *Quality Progress* 45-51.

Consumer Product Safety Commission (CPSC). 2012a. *Frequently Asked Questions*, Downloaded from: http://www.cpsc.gov/about/faq.html, on June 23, 2012.

Consumer Product Safety Commission (CPSC). 2012b. *2013 Performance Budget*.

Coombs, W.T. 2004. Impact of Past Crises on Current Crisis Communication: Insights from Situational Crisis Communication Theory. *Journal of Business Communication* **41** 265-289.

Coombs, W.T. 2007. Attribution Theory as a Guide for Post-Crisis Communication Research. *Public Relations Review* **33** 135-139.

Coombs, W.T., S.J. Holladay. 1996. Communication and Attributions in a Crisis: An Experimental Study in Crisis Communication. *Journal of Public Relations Research* **8**(4) 279-295.

Coombs, W.T., S.J. Holladay. 2002. Helping Crisis Managers Protect Reputational Assets: Initial Tests of the Situational Crisis Communication Theory. *Management Communication Quarterly* **16** 165-186.

Cox, D., Rich, S. 1964. Perceived Risk and Consumer Decision-Making: The Case of Telephone Shopping. *Journal of Marketing Research* **1** 32-39.

Crafton, S., G. Hoffer, R. Reilly. 1981. Testing the Impact of Recalls on the Demand for Automobiles. *Economic Inquiry* **19**(4) 694-703.

Crosby, P.B. 1979. *Quality is Free: The Art of Making Quality Certain*. McGraw-Hill, New York.

Crosby, P.B. 1984. *Quality Without Tears.* McGraw-Hill, New York, New York.

Cunningham, S.M. 1967. *The Major Dimensions of Perceived Risk*, in Cox, D.F., ed., Risk Taking and Information Handling in Consumer Behavior, Graduate School of Business Administration, Harvard University Press, Boston, Massachusetts, 82-108.

Darby, M.R., E. Karni. 1973. Free Competition and the Optimal Amount of Fraud. *Journal of Law and Economics* **16**(1) 67-88.

Dawar, N., M.M. Pillutla. 2000. Impact of Product-Harm Crises on Brand Equity: The Moderating Role of Consumer Expectations. *Journal of Marketing Research* **37**(2) 215-226.

de Matos, C.A., C.A.V. Rossi. 2006. Consumer Reaction to Product Recalls: Factors Influencing Product Judgement and Behavioral Intentions. *International Journal of Consumer Studies* 109-115.

Dowling, G., R. Staelin. 1994. A Model of Perceived Risk and Intended Risk-Handling Activity. *Journal of Consumer Research* **21(**1) 119-134.

Folkes, V.S. 1984. Consumer Reactions to Product Failure: An Attributional Approach. *Journal of Consumer Research* **10** 398-409.

Folkes, V. S. 1988a. Recent Attribution Research in Consumer Behavior: A Review and New Directions. *The Journal of Consumer Research* **14**(4) 548-565.

Folkes, V.S. 1988b. The Availability Heuristic and Perceived Risk. *The Journal of Consumer Research* **15**(1) 13-23.

Folkes, V.S., B. Kotsos. 1986. Buyers' and Sellers' Explanations for Product Failure: Who Done It? *Journal of Marketing* 74-80.

Food and Drug Administration (FDA). 2009a. Downloaded from http://www.fda.gov/Safety/Recalls/IndustryGuidance/ucm129259.htm, on August 9, 2011.

Food and Drug Administration (FDA). 2009b. Downloaded from: http://www.fda.gov/Safety/Recalls/MajorProductRecalls/default.htm, on May 27, 2012.

Food and Drug Administration (FDA). 2010. Trend Analysis Report on the Occurrence of Foodborne Illness Risk Factors in Selected Institutional Foodservice, Restaurant, and Retail Food Store Facility Types (1998-2008) - Conclusions and Areas of Future Study, Downloaded from http://www.fda.gov/Food/FoodSafety/RetailFoodProtection/FoodborneIllnessandRiskFactorReduction/RetailFoodRiskFactorStudies/ucm223400.htm, on May 25, 2012.

Food and Drug Administration (FDA). 2011a. Pathway to Global Product Safety and Quality: A Special Report. Downloaded from: http://www.fda.gov/AboutFDA/CentersOffices/OC/GlobalProductPathway/default.htm, on July 5, 2011.

Food and Drug Administration (FDA). 2011b. Downloaded from: http://www.fda.gov/Food/FoodSafety/FSMA/ucm250569.htm#food_imports, on May 4, 2011.

Food and Drug Administration (FDA). 2012. Enforcement Report. Downloaded from: http://www.fda.gov/Safety/Recalls/EnforcementReports/default.htm, on June 23, 2012.

Food Safety Inspection Service (FSIS) 2011. *FSIS Food Recalls*. Downloaded from: http://www.fsis.usda.gov/Fact_Sheets/FSIS_Food_Recalls/index.asp, on June 23, 2012.

Food Safety Inspection Service (FSIS). 2012. Downloaded from: http://www.fsis.usda.gov/about_fsis/Associated_Agencies_&_Partners/index.asp, on May 25, 2012.

Galbraith, J.R. 1974. Organizational Design: An Informational Processing View. *Interfaces* **4**(3) 28-36.

Gemünden, H. 1985. Perceived Risk and Information Search. A Systematic Meta-Analysis of the Empirical Evidence. *International Journal of Research in Marketing* **2**(2) 79-100.

Golan, E., B. Krissoff, F. Kuchler, L. Calvin, K. Nelson, G. Price. 2004. Traceability in the US Food Supply: Economic Theory and Industry Studies. *United States Department of Agriculture Economic Research Report Number 830*.

Government Accounting Office (GAO). 2000. Food Safety: Actions Needed by USDA and FDA to Ensure That Companies Promptly Carry Out Recalls, Downloaded from http://www.gao.gov/products/GAO-RCED-00-195 on April 1, 2011.

Government Accounting Office (GAO). 2004a. Federal Food Safety and Security System: Fundamental Restructuring Is Needed to Address Fragmentation and Overlap, Downloaded from http://www.gao.gov/products/GAO-04-588T on May 25, 2012.

Government Accounting Office (GAO). 2004b. Food Safety: USDA and FDA Need to Better Ensure Prompt and Complete Recalls of Potentially Unsafe Food, Downloaded from http://www.gao.gov/products/GAO-05-51 on April 1, 2011.

Gurhan-Canli, Z., R. Batra. 2004. When Corporate Image Affects Product Evaluations: The Moderating Role of Perceived Risk. *Journal of Marketing Research* **26** 197-205.

Gray, J.V., G. Anand, A.V. Roth. 2012. Management Standard Certifications: The Relationship between Time and Effectiveness. The Ohio State University Working Paper.

Gray, J., A.V. Roth, M. Leiblein. 2011a. Quality Risk in Offshore Manufacturing: Evidence from the Pharmaceutical Industry. *Journal of Operations Management* **29** 737-752.

Gray, J. V., A.V. Roth, B. Tomlin. 2009a. The Influence of Cost and Quality Priorities on the Propensity to Outsource Production. *Decision Sciences* **40**(4) 697-726.

Gray, J., A.V. Roth, B. Tomlin, 2011b. Quality Risk and Contract Manufacturing: Theory and Empirical Evidence. The Ohio State University Working Paper.

Gray, J.V., A.V. Roth, B. Tomlin. 2012. Quality Risk and Contract Manufacturing: Theory and Empirical Evidence. The Ohio State University Working Paper.

Gray, J. V., B. Tomlin, A.V. Roth. 2009b. Outsourcing to a Powerful Contract Manufacturer: The Effect of Learning-by-Doing. *Production and Operations Management* **18**(5) 487-505.

Gryna, F.M. 1999. *Quality and Costs*. in J.M. Juran, A.B. Godfrey, eds. Juran's Quality Handbook, 5th edition. McGraw-Hill, New York, NY, 8.1-8.26.

Hall, D. 2012. Essays on Sourcing Decisions. *Doctoral Dissertation*, Clemson University, Clemson, South Carolina.

Hallman, W.K., C.L. Cuite, N.H. Hooker. 2009. *Consumer Responses to Food Recalls: 2008 National Survey Report*. Food Policy Institute Rutgers New Jersey Agricultural Experiment Station.

Hair, J.F., R.L. Tatham, R.E. Anderson, W. Black. 1998. *Multivariate Data Analsyis*, *5th edition.* Prentice Hall, Upper Saddle River, New Jersey.

Harhoff, D., S. Wagner. 2009. The Duration of Patent Examination at the European Patent Office. *Management Science* **55**(12) 1969-1984.

Heider, F. 1958. *The Psychology of Interpersonal Relations*. Wiley, New York, New York.

Haunschild, P.R., M. Rhee. 2004. The Role of Volition in Learning: The Case of Automotive Recalls. *Management Science* **50**(11) 1545-1560.

Hoffer, G., S.Pruitt, R.Reilly. 1988. The Impact of Product Recalls on the Wealth of Sellers: A Reexamination. *The Journal of Political Economy* **96**(3) 663-670.

Hora, M., H. Bapuji, A.V.Roth. 2011. Safety Hazard and Time to Recall: The Role of Recall Strategy, Product Defect Type, and Supply Chain Player in the U.S. Toy Industry. *Journal of Operations Management* **29** 766-777.

Hosmer, D.W., S. Lemeshow, S. May. 2008. *Applied Survival Analysis: Regression Modeling of Time-to-Event Data, 2nd edition*. John Wiley & Sons, Inc., Hoboken, New Jersey.

Hughes, D. 2004. *Food Supply Chain Management*, M.A. Bourlakis & P.W.H. Wieghtman, eds. Blackwell Publishing, Oxford, UK.

Institute of Medicine and National Research Council of the National Academies. 2010. *Enhancing Food Safety: The Role of the Food and Drug Administration*, Wallace, R.B. and M. Oria, eds., The National Academy Press, Washington, DC.

Ittner, C.D. 1992. The Economics and Measurement of Quality Costs: An Empirical Investigation. *Doctoral Dissertation,* Harvard University, Cambridge, Massachusetts.

Jarrell, G., S. Peltzman. 1985. The Impact of Product Recalls on the Wealth of Sellers. *Journal of Political Economy* **93**(3) 512-536.

Jerardo, A. 2008. What Share of U.S. Consumed Food Is Imported? *AmberWaves* February 2008, Downloaded from www.ers.usda.gov/amberwaves, on May 25, 2012.

Jolly, D.W. and J.C. Mowen. 1985. *Product Recall Communications: The Effects of Source, Media, and Social Responsibility Information*, in E.C. Hirschman and M.B. Holbrook, eds., Advances in Consumer Research Volume 12 Association for Consumer Research, Provo, Utah, 471-475.

Juran, J.M. 1969. Mobilizing for the 1970s. *Quality Progress* 8-17.

Juran, J.M. 1972. Product Safety. *Quality Progress* 18-27.

Juran, J.M. 1992. *Juran on Quality by Design: the New Steps for Planning Quality into Goods and Services.* The Free Press, New York, New York.

Kalbfleisch, J.D, R.L. Prentice. 2002. *The Statistical Analysis of Failure Time Data, 2nd Edition.* Wiley-Intersciences, Hoboken, New Jersey.

Kelley, H.H. 1972. *Causal Schemata and the Attribution Process* in E.E. Johns, D.E. Kanouse, H.H. Kelley, R.E. Nisbett, S. Valins, and B. Weiner, eds, Attribution: Perceiving the Causes of Behavior. General Learning, Morristown, New Jersey, 151-174.

Klein, J., N. Dawar. 2004. Corporate Social Responsibility and Consumers' Attributions and Brand Evaluations in a Product-Harm Crisis. *International Journal of Research in Marketing* **21** 203-217.

Kogan, N., M.A. Wallach. 1964. *Risk Taking: A Study in Cognition and Personality*, Holt, Rhinehart & Winston, New York, New York.

The Kroger Company, 2011. Downloaded from: http://www.thekrogerco.com/operations/operations_manufacturing.htm, on June 19, 2012.

Kumar, S., E.M. Budin. 2006. Prevention and Management of Product Recalls in the Processed Food Industry: A Case Study Based on An Exporter's Perspective. *Technovation* **26** 739-750.

Laufer, D. 2002. *Are Antecedents of Consumer Dissatisfaction and Consumer Attributions for Product Failures Universal?* in Advances in Consumer Research, Volume 29, eds. S. M. Broniarczyk and K. Nakamoto, Association for Consumer Research, Valdosta, Georgia, 312-317.

Laufer, D., K. Gillespie, B. McBride, S. Gonzalez. 2005. The Role of Severity in Consumer Attributions of Blame: Defensive Attributions in Product-Harm Crises in Mexico. *Journal of International Consumer Marketing* **17**(2/3) 33-50.

Laufer, D., W.T. Coombs. 2006. How Should a Company Respond to a Product Harm Crisis? The Role of Corporate Reputation and Consumer-Based Cues, *Business Horizons* **49**(5) 379–385.

Laufer, D., J.M. Jung. 2010. Incorporating Regulatory Focus Theory in Product Recall Communications to Increase Compliance with a Product Recall. *Public Relations Review* **36**(3) 147-151.

Lee, H., V. Padmanahaban, S.Whang. 1997. Information Distortion in a Supply Chain: The Bullwhip Effect. *Management Science* **43**(4) 546-558.

Lister, S.A., G.S. Becker. 2010. Food Safety: Foodborne Illness and Selected Recalls of FDA-Regulated Foods. Congressional Research Service, downloaded from http://www.nationalaglawcenter.org/assets/crs/R40916.pdf, on May 25, 2012.

Lyles, M., B. Flynn, M. Frohlich. 2008. All Supply Chains Don't Flow Through: Understanding Supply Chain Issues in Product Recalls. *Management and Organization Review* **4**(2) 167-182.

Marks, E. 2006. Put It In Reverse. Downloaded from http://www.managingautomation.com/maonline/magazine/read/view/Put_It_in_Reverse_12615688, on June 22, 2012.

Martinez, S.W. 2007. The US Food Marketing System: Recent Developments, 1997-2006. *United States Department of Agriculture Economic Research Report Number 42*.

Marsh, T.L., T.C. Schroeder, J. Minert. 2004. Impacts of Meat Product Recalls on Consumer Demand in the USA. *Applied Economics* **36** 897-909.

Mead, P.S, L, Slutsker, V.Dietz, L.F.McCaig, J.S Bresee, C.Shapiro, P.M.Griffin, R.V. Taux. 1999. Food-Related Illness and Death in the United States. *Emerging Infectious Diseases, Center for Disease Control and Prevention* **5**(5) 607-625.

Menor, L. J., A.V. Roth. 2009. Improving Perceptual Measurement in Operations Management Survey Research. Ivey Business School – University of Western Ontario and College of Business and Behavioral Science – Clemson University. Working Paper.

Mittal, V., W.A. Kamakura. 2001. Satisfaction, Repurchase Intent, and Repurchase Behavior: Investigating the Moderating Effect of Customer Characteristic*s*. *Journal of Marketing Research* **28** 131-142.

Mitchell, V. 1999. Consumer Perceived Risk: Conceptualisations and Models. *European Journal of Marketing* **33**(1/2) 163-195.

Moore, G. C., I. Benbasat. 1991. Development of an Instrument to Measure the Perceptions of Adopting and information Technology Innovation. *Information Systems Research* **2**(3) 192-222.

Mowen, J.C. 1980. *Further Information on Consumer Perceptions of Product Recalls*, in Advances in Consumer Research Volume 7, eds. J.C. Olson, Association for Consumer Research, Ann Arbor, Michigan, 519-523.

Mowen, J.C., D. Jolly, G.S. Nickell. 1981. *Factors Influencing Consumer Responses to Product Recalls: A Regression Analysis Approach*, in Advances in Consumer Research Volume 8, eds. K.B. Monroe, Association for Consumer Research, Ann Arbor, Michigan, 405-407.

National Highway Traffic Safety Administration (NHTSA). 2006. Motor Vehicles Defects and Recalls. *DOT HS 808 795*.

Nelson, P. 1970. Information and Consumer Behavior. *Journal of Political Economy* **78**(2) 311-329.

Nestle, M. 2003. *Safe Food: Bacteria, Biotechnology, and Bioterrorism*. University of California Press, Berkeley, California.

Ollinger, M., D. Moore. 2009. The Interplay of Regulation and Market Incentives in Providing Food Safety. *United States Department of Agriculture Economic Research Report Number 75*.

Oliver, R.L. 1993. Cognitive, Affective, and Attribute Bases of the Satisfaction Response. *Journal of Consumer Research* **20** 418-430.

Oliver, R.L., W.S. DeSarbo. 1988. Response Determinants in Satisfaction Judgments. *Journal of Consumer Research* **14** 495-507.

Oliver, R.L, J.E. Swan. 1989. Equity and Disconfirmation Perceptions as Influences on Merchant and Product Satisfaction. *Journal of Consumer Research* **16** 372-383.

Osterholm, M.T. 2011. Foodborne Disease in 2011 – The Rest of the Story. *New England Journal of Medicine* **364** 889-891.

Packman, J.M. 1998. Civil and Criminal Liability Associated with Food Recalls. *Food & Drug Law Journal* **53** 437-452.

Pearson, C. M. and J.A. Clair. 1998. Reframing Crisis Management. *Academy of Management Review* **23**(1) 59-76.

Platt, E., B. Duronio. 2012. 22 Companies Who Are Addicted to Walmart. Downloaded fromhttp://www.businessinsider.com/22-companies-who-are-completely-addicted-to-walmart-2012-6?op=1, on June 23, 2012.

Pruitt, S.W., D.R. Peterson. 1986. Security Price Reactions Around Product Recall Announcements. *The Journal of Financial Research* **9**(2) 113-122.

Reilly, R., G. Hoffer. 1983. Testing the Impact of Recalls on the Demand for Automobiles. *Economic Inquiry* **21**(47) 444-458.

Rhee, M., P. R. Haunschild. 2006. The Liability of a Good Reputation: A Study of Product Recalls in the U.S. Automobile Industry. *Organizational Science* **17**(1) 101-117.

Roberts, M.T. 2004. Mandatory Recall Authority: A Sensible and Minimalist Approach to Improving Food Safety. *Working Paper 258.* The Berkeley Electronic Press.

Roberts, T. 2007. WTP Estimates of the Societal Costs of U.S. Food-Borne Illness. *American Journal of Agricultural Economics* **89**(5) 1183-1188.

Roth, A.V., C. Giffi, G. Seal. 1992. *Operating Strategies for the 1990's: Elements Comprising World Class Manufacturing,* in Manufacturing Strategy, Process and Content, C. Voss, ed., Chapman & Hall/Van Norstrand Publishers, London, UK, 133-165.

Roth, A. V., J. Gray, J. Shockley, H-H. Weng. 2009. The Devil Is in the Details: The Use of Secondary Data for Measuring Performance in OM Research, *4th Workshop on Empirical Research in Operations Management*, Wharton, University of Pennsylvania, Philadelphia, Pennsylvania, November 12-13, 2009.

Roth, A., R.Schroeder, X. Huang, M. M. Kristal. 2007. *Handbook of Metrics for Research in Operations Management: Multi-item Measurement Scales and Objective Items*. Sage Publications Inc., Los Angeles, California.

Roth, A.V., A. Tsay, M.E. Pullman, J.V. Gray. 2008 Reap What You Sow. *International Commerce Review* 8(1).

Roth, A.V., A. Tsay, M. E. Pullman, J.V. Gray. 2008. Unraveling the Food Supply Chain: Strategic Insights From China And The 2007 Recalls. *Journal of Supply Chain Management* **44(**1) 22-40.

Rupp, N.G. 2003. The Attributes of a Costly Recall: Evidence from the Automotive Industry. *Journal of Industrial Economics* **50**(2) 123-150.

Rungtusanatham, M., C. Wallin, S. Eckerd. 2011. The Vignette in a Scenario-Based Role-Playing Experiment. *Journal of Supply Chain Management* 9-16.

Salin, V., H.H. Hooker. 2001. Stock Market Reaction to Food Recalls. *Agriculture and Applied Economics Association*. **23**(1) 33-46.

Scallen, E., R.M.Hoekstra, F.J.Angulo, R.V.Tauxe, M. Widdowson, S.L. Roy, J.L. Jones, P.M. Griffin. 2011. Foodborne Illness Acquired in the United States—Major Pathogens, *Emerging Infectious Diseases*, *Center for Disease Control and Prevention* **17**(1) 7-15.

Scharff, R.L. 2012. Economic Burden from Health Losses Due to Foodborne Illness in the United States. *Journal of Food Protection* **75**(1) 123-131.

Shaver, K.G. 1985. *The Attribution of Blame: Causality, Responsibility and Blameworthiness*. Springer-Verlag, New York, New York.

Siomkos, G., G. Kurzbard. 1994. The Hidden Crisis in Product Harm Crisis Management. *European Journal of Marketing* **28**(2) 30-41.

Smith, N.C., R.J. Thomas, and J.A. Quelch. 1996. A Strategic Approach to Managing Product Recalls. *Harvard Business Review* 102-112.

Tabachnick, B.G., L.S. Fidell. 2007. *Using Multivariate Statistics, 5th edition*. Pearson Education, Inc. Boston, Massachusetts.

Taylor, J. 1974. The Role of Risk in Consumer Behavior. *The Journal of Marketing* **38(**2) 54-60.

Teratanavat, R., N.H. Hooker. 2004. Understanding the Characteristics of US Meat and Poultry Recalls: 1994-2002. *Food Control* **15** 359-367.

Teratanavat, R., V. Salin, N.H. Hooker. 2005. Recall Event Timing: Measures of Managerial Performance in U.S. Meat and Poultry Plants. *Agribusiness* **21**(3) 351-373.

Terwiesch, C., Z.J. Ren, T.H. Ho, M.A. Cohen. 2005. An Empirical Analysis of Forecast Sharing in the Semiconductor Equipment Supply Chain. *Management Science* **51**(2) 208-220.

Thirumalai, S., K.K. Sinha. 2011. Product Recalls in the Medical Device Industry: An Empirical Exploration of the Sources and Financial Consequences. *Management Science* **57**(2) 376-392.

Thomsen M.R., A. McKenzie. 2001. Market Incentives for Safe Foods: An Examination of Shareholder Losses from Meat and Poultry Recalls. *American Journal of Agricultural Economics* **83**(3) 526-538.

Thomsen, M.R., R. Shiptsova, S.J. Hamm. 2006. Sales Responses to Recalls for Listeria monocytogenes: Evidence from Branded Ready-to-Eat Meats. *Review of Agricultural Economics* **28**(4) 482-493.

Tsiros, M., V.Mittal. 2004. The Role of Attributions in Customer Satisfaction: A Reexamination. *The Journal of Consumer Research* **31**(2) 476-483.

Tu, Q., M.A. Vonderembse, T.S Ragu-Nathan, T.W. Sharkey. 2001. The Impact of Time-Based Manufacturing Practices on Mass Customization and Value to Customer. *Journal of Operations Management* **19(**2) 201-217.

United States Code of Federal Regulations Title 21 Food and Drugs, revised as of April 1, 2010.

Vachon, S., R.D. Klassen. 2002. An Exploratory Investigation of the Effects of Supply Chain Complexity on Delivery Performance. *IEEE Transactions on Engineering Management* **49**(3) 218-230.

Westbrook, R.A., R.L. Oliver. 1991. The Dimensionality of Consumption Emotion Patterns and Consumer Satisfaction. *Journal of Consumer Research* **18** 84-91.

Weiner, B., A. Kukla. 1970. An Attributional Analysis of Achievement Motivation. *Journal of Personality and Social Psychology* **15** 1-20.

Weiner, B. 1995. *Judgments of Responsibility*. Guilford Press, New York, New York.

Weiner, B. 2000. Attributional Thoughts About Consumer Behavior. *Journal of Consumer Research* **27**(3) 382-387.

White, T., R. Pomponi. 2003. Gain a Competitive Edge by Preventing Recalls. *Quality Progress* 41-49.

Wittenberger, K., E.Dohlman. 2010. Peanut Outlook: Impacts of the 2008-9 Foodborne Illness Outbreak Linked to Salmonella in Peanuts. *United States Department of Agriculture Economic Research Report Number OCS-10a-01*.

Yousuf, H. 2010. Recalls that Kill. *CNN Money,* March 23, 2010, Downloaded from http://money.cnn.com/galleries/2010/smallbusiness/1003/gallery.Recalls_that_Kill/index.htm, on May 24, 2012.

Zeelenberg, M., R.Pieters, 2004. Beyond Valence in Customer Dissatisfaction: A Review and New Findings on Behavioral Responses to Regret and Disappointment in Failed Services. *Journal of Business Research* **57**(4) 445-455.

APPENDICES

APPENDIX 2A
ESSAY 1 CONSTRUCT DEFINITIONS, DATA SOURCES AND DATA COLLECTION

Table 2A.1 Construct Definitions & Data Sources

Variable Type	Construct/ Variable Name	Operational Definition/Sample Measure	Data Source
Dependent Variable	Time to Recall – *timetorecall*	**Time to Recall** is the duration between T=0 (beginning of shelf life) and T_i*, the date of the recall announcement.	Enforcement Report, Press Release & industry standards for shelf life
	Recall Magnitude -Number of Products Recalled *noproducts*	**Number of products** listed individually in the press release.	Enforcement Report or Press Release
	Recall Reach - Downstream Distribution *local regional national*	**Downstream Distribution** is a proxy for the complexity of determining the scope of the recall, the number of states where recalled product was distributed. Downstream Distribution has been recorded as the number of stages and condensed into 3 categories (0=1-3; 1=4-20; 2>20 states).	Enforcement Report or Press Release
	Proactive or Reactive Recall Strategy *reactive*	**Proactive recalls** occur before any illness or injury is attributed at the agency level to a specific product. **Reactive recalls** occur after an illness or injury is attributed at the agency level to a specific product.	Enforcement Report or Press Release
	Supply Chain Recall Detection Competence - Detection Entity *detentbinary*	**Detection Entity** – the entity which detected the defect which is the basis for the recall as indicated by the enforcement report or press release. Detection Entity is coded as a binary variable, External (Agency/Consumer) or Internal (Recalling Firm/Supplier)	Enforcement Report or Press Release

Variable Type	Construct/ Variable Name	Operational Definition/Sample Measure	Data Source
	Supply Chain Entity *scentity*	**Supply Chain Entity** – a categorization of the recalling entity – the firm making the recall (e.g. agency, manufacturer, distributor, retailer). In practice since all recalls in our database were voluntary, this did not include the agency category. In the final analysis, the categorization was collapsed to manufacturer (0) and distributor/retailer (1).	Publically available databases of primary SIC or NAIC codes for each recalling firm
	Defect Type *pathogen*	Four **defect types** were coded: labeling/allergens (0), pathogen (1), packaging (2), and contaminant or stability issue (3). In the final analysis, the categorization was collapsed to pathogen (1) and all other defects (0).	Enforcement Report or Press Release
	Quality Process Maturity - Affected Production Period *prodperiod*	**Affected production period** represents the number of days between the production or expiration of first affected product and last affected product listed in the recall announcement, indicating the duration of the defect causing the recall. Minimum of 1 day where no range is present.	Enforcement Report or Press Release

Variable Type	Construct/ Variable Name	Operational Definition/Sample Measure	Data Source
	RecallBreadth *recallbreadth*	**Recall breadth** indicates (Major=1; Other, Not major =0) FDA-designated "major" recalls – recalls which due to the number of products or other agency-determined characteristics require special communication efforts. Since 2008, five major recalls have been designated: Plainview Milk Cooperative (powdered milk), Basic Food Flavors (hydrolyzed vegetable protein), Peanut Corporation of America (peanuts/peanut products), Setton Pistachios (whole & shelled pistachios), and Galt, Wright County, etc. (shell eggs).	FDA website
Control Variables	Year Dummy *yr_2008, yr_2009, yr_2010*	**Year** in which recall is announced	Enforcement Report or Press Release
	Product Category *Cat0_refridge Cat1_frozen Cat2_shelfstable*	**Product categories** are based on processing & storage attributes. A 3 category operationalization has been used: 1. Refrigerated 2. Frozen 3. Shelf Stable	Enforcement Report & industry standards for processing
	Private or Public *public*	The firm's status as a **private or publicly** traded company at the time of the recall (Public=1; Private=0).	Databases of firm information, e.g., Mergent Online

Variable Type	Construct/ Variable Name	Operational Definition/Sample Measure	Data Source
	Firm Size *firmempl* *firmrev*	**Firm size** as measured by annual revenue or the number of firm employees.	Databases of firm information, e.g., Mergent OnLine, Manta, or annual reports
	Firm Cluster *firmcluster*	**Firm Cluster** is a unique dummy variable assigned to each firm within the sample to enable the use of Stata's clustering option which allows errors within a cluster to be correlated.	

Data Collection

Data were collected by accessing the FDA's online archives of weekly enforcement reports and press releases for food products for the years of 2008-2010. Enforcement report information was matched to press releases to develop an initial set of 1,602 press releases for consideration. Because the dependent variable is a measure of recall timing, we exclude any press releases which do not contain enough information about production, distribution or expiration dates which are necessary to calculate the dependent variable. This reduces our sample to a total of 846 press releases.

The remaining press releases and enforcement reports were coded by three different persons using a set of scales which were developed during a pilot analysis of 100 press releases and refined over time to ensure internal consistency and external validity. Approximately 20% of the total sample was coded by more than one person. Inter-rater reliability was high (>97%) and all cases where disagreement occurred were readily resolved through discussion among the raters.

Sample Press Releases

The following press releases correspond to the examples used in the text. Each case in the sample has a corresponding press release.

Example 1 – Concentrated Beverage

U.S Department of Health & Human Services

a A A

U.S. Food and Drug Administration
Protecting and Promoting *Your* Health

A to Z Index | Follow FDA | FDA Voice Blog

SEARCH

Most Popular Searches

Home | Food | Drugs | Medical Devices | Vaccines, Blood & Biologics | Animal & Veterinary | Cosmetics | Radiation-Emitting Products | Tobacco Products

Safety

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Recall -- Firm Press Release

FDA posts press releases and other notices of recalls and market withdrawals from the firms involved as a service to consumers, the media, and other interested parties. FDA does not endorse either the product or the company.

Tipu's Tiger Chai, Inc Recalls Tipus Tiger Chai Concentrate Because of a Possible Health Risk

Contact:
Bipin Patel
(406) 240 9979

FOR IMMEDIATE RELEASE -- June 17, 2008 -- Tipu's Tiger Chai Inc, of **Missoula, Montana** is voluntarily recalling its Tipu's Tiger Chai Concentrate because it has the potential to be contaminated with Clostridium botulinum, a bacterium which can cause life-threatening illness or death. Consumers are warned not to use the product even if it does not look or smell spoiled.

Botulism, a potentially fatal form of food poisoning, can cause the following symptoms: general weakness, dizziness, double-vision and trouble with speaking or swallowing. Difficulty in breathing, weakness of other muscles, abdominal distension and constipation may also be common symptoms. People experiencing these problems after consuming this product should seek immediate medical attention.

Tipu's Tiger Chai Concentrate was distributed, primarily to stores and coffee kiosks in western Montana and one café in Prescott, Arizona using the concentrate for mixed beverages sold on-site. Limited distribution of the bottled product was made directly to consumers in Western Montana.

The product is distributed in plastic half gallon (1.89L) units labeled as "Tipu's Tiger Chai, Chai Concentrate". The lid or neck of bottle states "refrigerate after opening" followed by dates of 09/23/09 through and including 05/22/10.

Please note that NO illnesses have been reported to date.

Through a records audit, the pH level of the product manufactured during this period were found to be higher than required by FDA standards.

Any consumers who may have purchased this product are urged to return it to the place of purchase for a full refund. Consumers with questions may contact the company at 1-(888)-506-2424 .

#

Photo: Product Label

RSS Feed for FDA Recalls Information [what's this?]

Page Last Updated: 05/21/2009
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Example 2 Fresh Cut Packaged Produce

U.S Department of Health & Human Services

a A A

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Recall -- State Press Release

FDA posts press releases and other notices of recalls and safety alerts from states as a service to consumers, the media, and other interested parties. FDA is not responsible for the content of these notices.

DSHS Orders Sangar Produce to Close, Recall Products

News Media Contact:
Carrie Williams, Press Officer,
512-458-7119 or 512-965-7198

FOR IMMEDIATE RELEASE - October 20, 2010 - The Texas Department of State Health Services today ordered Sangar Fresh Cut Produce in San Antonio to stop processing food and recall all products shipped from the plant since January. The order was issued after laboratory tests of chopped celery from the plant indicated the presence of *Listeria monocytogenes*, a bacterium that can cause severe illness.

State law allows DSHS to issue such orders when conditions exist that pose "an immediate and serious threat to human life or health."

The recalled products – primarily cut fresh produce in sealed packages – were distributed to restaurants and institutional entities, such as hospitals and schools, and are not believed to be sold in grocery stores.

The testing was done as part of a DSHS investigation into 10 listeriosis cases, including five deaths, reported to the department over an eight-month period. Six of the 10 cases have been linked to chopped celery from the Sangar plant. The illnesses occurred in Bexar, Travis and Hidalgo counties. All of the illnesses were in people with serious underlying health problems.

Health officials said pinpointing a *Listeria* source is often difficult due to the small number of cases, the illness' long incubation period and difficulty collecting complete information about what people ate.

DSHS inspectors also found sanitation issues at the plant and believe the *Listeria* found in the chopped celery may have contaminated other food produced there. The department found a condensation leak above a food product area, soil on a preparation table and hand washing issues. DSHS food safety personnel are contacting distributors, restaurants and institutions believed to have received the recalled products to ensure they are taking appropriate action to protect consumers.

DSHS continues to investigate possible sources of contamination and where the products were distributed. Sangar's customers are advised to discard or return the products. Cooking the products is not recommended.

Symptoms of listeriosis can include fever, muscle aches, diarrhea and vomiting. People with these symptoms should consult a physician. Symptoms typically occur three to 70 days after exposure. The disease affects primarily older people, pregnant women, newborns and people with weakened immune systems.

The order prohibits the plant from reopening without DSHS approval.

###

RSS Feed for FDA Recalls Information [what's this?]

Page Last Updated: 10/22/2010
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Time to Recall

A further complication is introduced in determining our dependent variable because of the lack of standardization of the use of dates within the recall press releases. Because

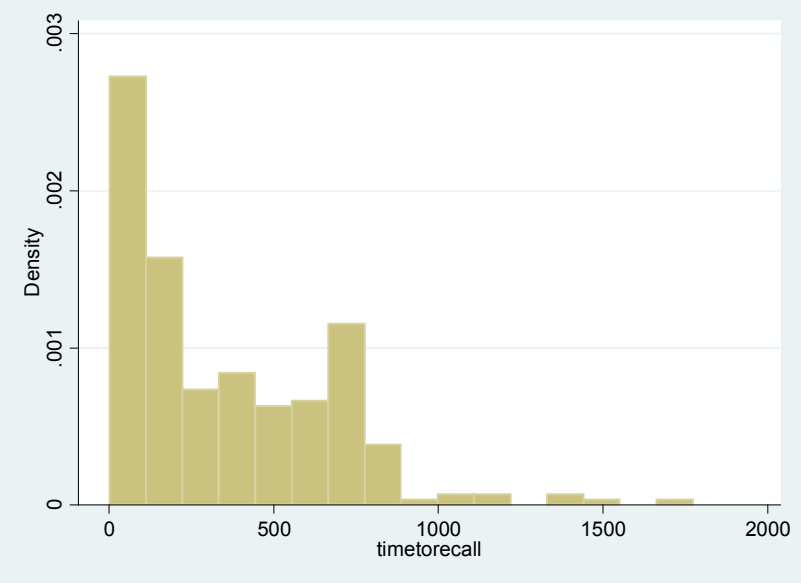
the purpose of including dates and other identifying features specific to the recalled products is to assist consumers in recognizing affected items and because product dating is not standardized, press releases contain different types of date-related information. In our sample we have used a combination of expiration, production and distribution dates and product shelf life sources to calculate the dependent variable. While product shelf lives are determined by the producer, category-specific shelf life information is available through agricultural extension offices, academic papers which study different preservation and product types, and consumer guidance.

Table 2A provides summary statistics for the time to recall variable. Figure 1A illustrates the distribution of time to recall which displays the strong skew which is often found in duration data.

Table 2A.2 Summary Statistics for *timetorecall* (T_i*)

Variable	Observations	Mean	Standard Deviation	Median	Minimum	Maximum
timetorecall	258	350.752	322.172	239.5	1	1773

Figure 2A.1 – Distribution of *timetorecall*



Detection Entity & Supply Chain Recall Detection Competence

Detection entity, a proxy for supply chain recall detection competence (SCRDC) is operationalized as the entity that detects the defect which results in a product recall. We use a binary characterization of detection entity with the following operationalization:

1. ***Internal detection entity*** – defects detected by the recalling firm (manufacturer, distributor or retailer) or their supplier; and
2. ***External detection entity*** – defects detected by a consumer or a regulatory agency.

This operationalization is the most parsimonious and theoretically consistent conceptualization of the construct, however we examined the data in more detail in order to understand the nature of detection entity.

Detection entity was coded directly from the recall press releases. Based on information provided in the press release we could distinguish between the following mutually exclusive detection entities:

1. ***Agency detections*** –characterized by statements regarding agency inspections and/or testing that resulted in a recall.
2. ***Consumer detections*** –characterized by a defect being discovered through customer complaint.
3. ***Recalling firm (Manufacturer/Distributor/Retailer)*** – characterized by the firm making the recall announcement indicating that their organization or internal processes detected the defect.
4. ***Supplier to recalling firm*** – characterized by a statement by the recalling firm that they were notified of a defect by a supplier.

These categories represent a comprehensive and mutually exclusive categorization of how a defect that results in a recall may be discovered. To further parse out detection entity among manufacturers, distributors and retailers, we coded the supply chain entity (SCEntity) conducting the recall by searching public and private firm databases to determine the primary NAICS code for the firm conducting the recall (Hora et al., 2011). Due to the relatively small number of distributors conducting recall announcements, we collapsed this variable to a binary categorization (0=producer/manufacturer; 1=distributor/retailer). We then matched the SCEntity and Detection Entity classifications in an attempt to create a five category Detection Entity variable. Table 2B below tabulates SCEntity versus the four category operationalization of Detection Entity.

Table 2A.3 Full Sample (N=434) SCEntity by Detection Entity (4 category)

	Detection Entity (Four Category Operationalization)				
SCEntity	**0 - Agency**	**1 – Consumer**	**2 – Recalling Firm**	**3 – Supplier to Recalling Firm**	**Total**
0 - producer	11	15	14	196	236
1 – distributor/ retailer	23	7	2	166	198
Total	34	22	16	362	434

While we would ideally like to split our categorization of Recalling Firm as a Detection Entity into Producer (SCEntity=0) and Distributor/Retailer (SCEntity=1), we cannot do so in this sample because only 2 cases correspond to a Distributor/Retailer detecting the defect.

Downstream Distribution

We first look at the distribution of the variable labeled *states*, which is an indicator of the number of states in which the recalled products were distributed, with a range of 1 to 50, noting that the distribution appears bimodal (Figure 2A). We therefore examine a number of possible scale adjustments, including a 5-category (Figure 3A), 3-category (Figure 4A), and a binary (Figure 5A) operationalization of this construct. Based on our examination of the distribution of each operationalization, we have chosen to use a 3-category scale where the number of states in which the recalled product was distributed is categorized as Local (1-3 states), Regional (4-20 states) or National (>20 states). Note that while the National category contains a total of 4 cases which are distributed in fewer than 50 states, however, we argue that these cases correspond to a natural separation in

the data between 19 states, which falls into the category of Regional, and the next value of 28 states which falls into the category of National.

Figure 2A.2 Histogram of *states* (1-50)

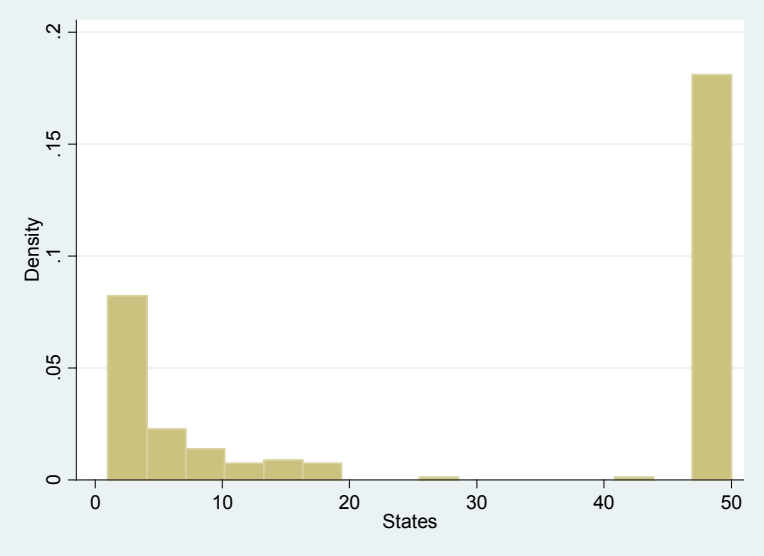
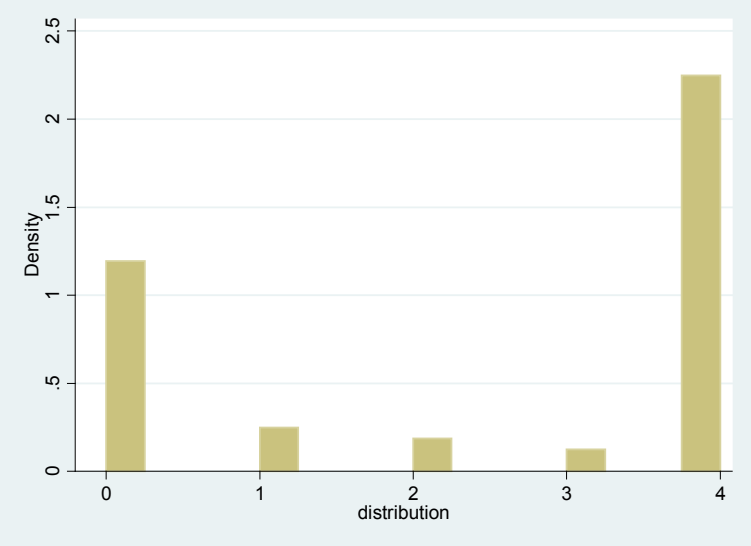
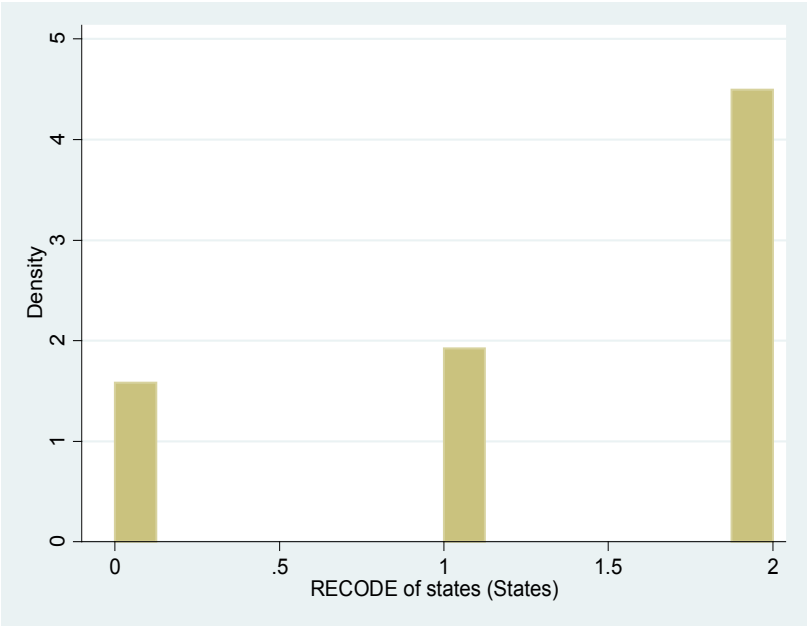


Figure 2A.3 Histogram of 5-category operationalization of *distribution*[1]



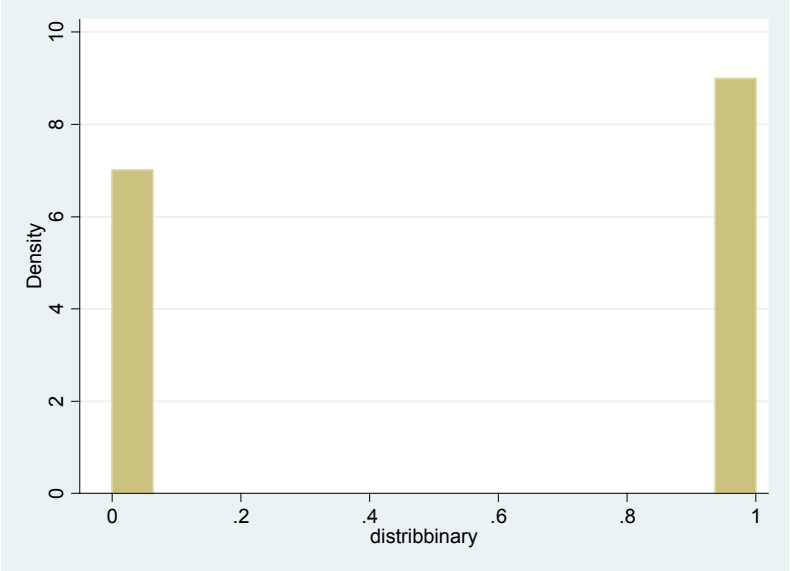
Note 1: 0=1-5 states; 1=6-10 states; 2=11-15; 3=16-20; 4=>20

Figure 2A.4 Histogram of 3-category distribution



Note 1: Where Local =1-3 states=0; Regional=4-20 states=1; National=21-50 states=2.

Figure 2A.5 Histogram of *distribbinary* (0=1-20 states; 1=>20 states)



Original Code Book

Data was recorded in a spreadsheet formatted for the task with one worksheet per press release to minimize opportunities for transcription error between cases. The following table is the code book which was used to define how the original data was coded from the press releases and enforcement reports. Not all of the data listed in this code book is used in this study.

Item Number	Item
1	**Voluntary or Agency-Led (1 = Agency-led)**
2	**Extension of Prior Recall? (1 = Extension of Prior)**
3	**If extension, extension of what (date/firm)?**
4	**Enforcement Report (confirm date this recall is listed in Enforcement Report)**
5	**Recall Class (1, 2 or 3) Confirm with Enforcement Report**
6	**Agency indicates "major" recall (1 = major)** **This is indicated by special FAQ/reports provided by agency on the recall – see compiled list of major recalls**
7	**Recalling Firm Name**
8	**Location of Recalling Firm**
9	**Product Name** **If > 1, indicate "multiple"**
10	**Recall Announcement Date**
11	**Food or Drug (1= Drug; 0=Food)** **Animal feeds = food** **Animal medicine = drug**

Item Number	Item
12	**Product Category (1-18)** 1 – Fresh produce 2 – Refrigerated, other 3 – Dairy 4 – Seafood, fresh 5 – Eggs (in shell) 6 – Baked goods 7 – Frozen mixtures 8 – Frozen seafood 9 – Other, shelf stable 10 – Nuts, dried fruits, dried vegetables 11 - Pet/Animal food 12 - Canned goods 13 – Injectable drug (human and vet) 14 – OTC drug 15 - OTC vet 16 – Prescription drug, non-injectable (human) 17- Vet drug, prescription 18 - Supplements
13	**Number of Products in Recall Notice** **(Continuous – count them as listed in the notice. If listed separately, same product in different size container is counted as an additional product)**
14	**Proactive/Reactive (0,1) REACTIVE - 1**
15	**# of Injury/Illness/Fatality (typically "no injury" indicated in press release; otherwise, check Enforcement Report; CDC investigation, if necessary)**
16	**Locus of Control (0,1, 2) EXTERNAL - 1; Not given = 2** **Internal locus of control = 0 failure is within recalling firm** **External locus of control = 1 failure is outside recalling firm** **Not given = 2**
17	**Stability (0,1)** **0 = no corrective action indicated** **1 = corrective action indicated including preventative future measures, ongoing investigation** Does not include shutting down production
18	**Detection Method (1-5; NA)** **CHECK ALL THAT APPLY** **1** – Consumer Complaint 2 - Agency inspection or agency testing (including CDC investigation of illnesses) **3** – Supplier testing/recall/investigation **4** – Internal (firm) testing/investigation 5 – Other (specify) **NA** – Cannot judge based on the information provided in the announcement.
19	**Import** (is the product, not the ingredients, an import?) (0,1). Import = 1
20	**Imported from** (if previous code = 1, indicate country product is imported from)

Item Number	Item
21	**Brand Attribution (0,1) Brand Attribution = 1** If the recalling firm's name (or part of name) or a trademarked brand name is included in the product name and/or product packaging = 1 Brand attribution may be confirmed using photos of product provided as part of recall information.
22	**Defect Type (record all that apply)** 1. Pathogen 2. Labeling error (including undeclared ingredients, allergens) 3. Packaging 4. Sterility 5. Contaminant, other (includes extraneous matter & ingredient substitution) **6.** Other, specify
23	**Downstream Distribution (# states product distributed in - count)**
24	**Manufacturer (as listed in Enforcement Report)**
25	**Location of manufacturer (record if available – typically manufacturing firm is listed in Enforcement Report)**
26	**Volume (Enforcement Report)**
27	**Volume Units (as given in Enforcement Report)**
28	**Public or Private (0,1) 1 = Private**
29-30	**Earliest production date** **Latest production date**
31-32	**Earliest expiration date** **Latest expiration date**

APPENDIX 2B
ESSAY 1 ANALYSIS

Figure 2B.1 Output, Model 1a Estimates

```
. streg  public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable P
> athogen Regional National yr_2009 yr_2010  noprodXprodperiod regbynoprod Natlbynoprod  DetectXReg DetectXNatl breadthXp
> rodperiod  detectionXnoprod detectXbreadth, dist(lnormal) vce(cluster firmcluster)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -779.78271
Iteration 1:   log pseudolikelihood =  -515.3193
Iteration 2:   log pseudolikelihood = -512.57961
Iteration 3:   log pseudolikelihood = -512.57796
Iteration 4:   log pseudolikelihood = -512.57796

Fitting full model:

Iteration 0:   log pseudolikelihood = -512.57796
Iteration 1:   log pseudolikelihood = -480.63588
Iteration 2:   log pseudolikelihood = -478.47125
Iteration 3:   log pseudolikelihood = -478.46945
Iteration 4:   log pseudolikelihood = -478.46945

Lognormal regression -- accelerated failure-time form

No. of subjects      =          258                 Number of obs   =       258
No. of failures      =          258
Time at risk         =        90494
                                                    Wald chi2(23)   =    229.94
Log pseudolikelihood =   -478.46945                 Prob > chi2     =    0.0000

                          (Std. Err. adjusted for 201 clusters in firmcluster)
```

_t	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
public	-.91826	.4987438	-1.84	0.066	-1.89578	.0592599
firmrev	6.66e-06	8.84e-06	0.75	0.451	-.0000107	.000024
firmempl	-2.28e-07	2.50e-06	-0.09	0.928	-5.13e-06	4.68e-06
recallbrea~h	1.194376	.3456558	3.46	0.001	.5169032	1.871849
reactive	.099646	.2599794	0.38	0.702	-.4099044	.6091963
detentbinary	.9817505	.6016975	1.63	0.103	-.197555	2.161056
prodperiod	.0022877	.0009465	2.42	0.016	.0004327	.0041428
noproducts	.0174613	.0166233	1.05	0.294	-.0151198	.0500424
cat1_frozen	1.657273	.6231316	2.66	0.008	.4359578	2.878589
cat2_shelf~e	2.199458	.3897376	5.64	0.000	1.435587	2.96333
Pathogen	.1843157	.5134555	0.36	0.720	-.8220386	1.19067
Regional	.6533058	.3372491	1.94	0.053	-.0076903	1.314302
National	-.1888054	.4209648	-0.45	0.654	-1.013881	.6362705
yr_2009	-.0719821	.4609888	-0.16	0.876	-.9755035	.8315393
yr_2010	.0971073	.4728534	0.21	0.837	-.8296683	1.023883
noprodXpro~d	-.0000213	.0000308	-0.69	0.490	-.0000817	.0000391
regbynoprod	-.429635	.2337168	-1.84	0.066	-.8877116	.0284415
Natlbynoprod	.1261915	.1739725	0.73	0.468	-.2147883	.4671713
DetectXReg	-.6495828	.6573978	-0.99	0.323	-1.938059	.6388932
DetectXNatl	-.0459929	.6874248	-0.07	0.947	-1.393321	1.301335
breadthXpr~d	-.002004	.0010313	-1.94	0.052	-.0040253	.0000173
detectionX~d	.0025591	.0201312	0.13	0.899	-.0368973	.0420155
detectXbre~h	.0842019	.414835	0.20	0.839	-.7288598	.8972637
_cons	1.838316	.6199425	2.97	0.003	.6232514	3.053381
/ln_sig	.4355942	.0791859	5.50	0.000	.2803927	.5907958
sigma	1.545881	.122412			1.323649	1.805425

Hypothesized interactions: H2a: Detection X Number of Products; H2b: Detection X Regional Detection X National.

Higher order terms included as mis-specification check: Number of Products X Affected Production Period; Detection X Recall Breadth; Regional X Number of Products, National X Number of Products; Recall Breadth X Affected Period.

Results: See Figure 2B.1. Hypothesized interaction terms are not significant (retain in model). Additional interactions are not significant except for Recall Breadth X Affected Period. Retain Recall Breadth X Affected Period in model.

Figure 2B.2 Output, Model 1b Estimates

```
. streg  public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable P
> athogen Regional National yr_2009 yr_2010  noprodXprodperiod regbynoprod Natlbynoprod  DetectXReg DetectXNatl breadthXp
> rodperiod  detectionXnoprod detectXbreadth, dist(loglogistic) vce(cluster firmcluster)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -573.88058
Iteration 1:   log pseudolikelihood = -516.16367
Iteration 2:   log pseudolikelihood = -501.93514
Iteration 3:   log pseudolikelihood = -501.84949
Iteration 4:   log pseudolikelihood = -501.84946

Fitting full model:

Iteration 0:   log pseudolikelihood = -501.84946
Iteration 1:   log pseudolikelihood = -470.86866
Iteration 2:   log pseudolikelihood = -457.69648
Iteration 3:   log pseudolikelihood = -457.16457
Iteration 4:   log pseudolikelihood = -457.16341
Iteration 5:   log pseudolikelihood = -457.16341

Loglogistic regression -- accelerated failure-time form

No. of subjects      =          258                 Number of obs   =       258
No. of failures      =          258
Time at risk         =        90494
                                                    Wald chi2(23)   =    215.37
Log pseudolikelihood =   -457.16341                 Prob > chi2     =    0.0000

                          (Std. Err. adjusted for 201 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |  -.4184976   .3315999    -1.26   0.207    -1.068421    .2314262
     firmrev |   2.70e-06   6.38e-06     0.42   0.672    -9.80e-06    .0000152
    firmempl |  -9.79e-07   1.87e-06    -0.52   0.601    -4.65e-06    2.69e-06
recallbrea~h |   1.564041    .314508     4.97   0.000     .9476172    2.180466
    reactive |   .0474953    .219995     0.22   0.829     -.383687    .4786776
detentbinary |   1.322987   .5769314     2.29   0.022     .1922218    2.453751
  prodperiod |   .0024306   .0008935     2.72   0.007     .0006794    .0041817
  noproducts |   .0127068   .0109912     1.16   0.248    -.0088356    .0342492
 cat1_frozen |   1.779548   .5853845     3.04   0.002     .6322153     2.92688
cat2_shelf~e |   2.080562   .4271405     4.87   0.000     1.243382    2.917742
    Pathogen |   .0229607    .469137     0.05   0.961     -.896531    .9424524
    Regional |   .4100843   .3251966     1.26   0.207    -.2272895    1.047458
    National |   .0057826   .3294235     0.02   0.986    -.6398757    .6514409
     yr_2009 |   .1612472   .4575759     0.35   0.725     -.735585    1.058079
     yr_2010 |   .0242285   .4514663     0.05   0.957    -.8606292    .9090861
noprodXpro~d |  -4.38e-06    .000022    -0.20   0.842    -.0000475    .0000387
 regbynoprod |  -.1983122   .1866565    -1.06   0.288    -.5641521    .1675278
Natlbynoprod |   .0081877   .1223336     0.07   0.947    -.2315818    .2479572
  DetectXReg |   -.829853   .5542304    -1.50   0.134    -1.916125    .2564186
 DetectXNatl |  -.4719546   .5944863    -0.79   0.427    -1.637126    .6932171
breadthXpr~d |   -.002311    .000955    -2.42   0.016    -.0041828   -.0004392
detectionX~d |   .0023807   .0145847     0.16   0.870    -.0262047    .0309661
detectXbre~h |  -.1150818   .4268033    -0.27   0.787    -.9516008    .7214372
       _cons |   1.753374   .7169508     2.45   0.014     .3481758    3.158571
-------------+----------------------------------------------------------------
     /ln_gam |  -.2783955    .099501    -2.80   0.005    -.4734139   -.0833771
-------------+----------------------------------------------------------------
       gamma |   .7569974    .075322                      .6228722    .9200042
------------------------------------------------------------------------------

.
```

Hypothesized interactions: H2a: Detection X Number of Products; H2b: Detection X Regional Detection X National.

Higher order terms included as misspecification check: Number of Products X Affected Production Period; Detection X Recall Breadth; Regional X Number of Products, National X Number of Products; Recall Breadth X Affected Period.

Results: See Figure 2B.2. Hypothesized interaction terms are not significant (Detection X Regional is significant at $p<.07$). Retain in model. Additional interactions are not significant except for Recall Breadth X Affected Period. Retain Recall Breadth X Affected Period in model.

Figure 2B.3 Output, Model 1c Estimates

```
. streg  public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable P
> athogen Regional National yr_2009 yr_2010  noprodXprodperiod regbynoprod Natlbynoprod  DetectXReg DetectXNatl breadthXp
> rodperiod  detectionXnoprod detectXbreadth, dist(weibull) vce(cluster firmcluster) time

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -468.05622
Iteration 1:   log pseudolikelihood = -463.40104
Iteration 2:   log pseudolikelihood = -463.38672
Iteration 3:   log pseudolikelihood = -463.38671

Fitting full model:

Iteration 0:   log pseudolikelihood = -463.38671
Iteration 1:   log pseudolikelihood = -428.43957
Iteration 2:   log pseudolikelihood =  -419.2948
Iteration 3:   log pseudolikelihood = -418.87816
Iteration 4:   log pseudolikelihood = -418.87649
Iteration 5:   log pseudolikelihood = -418.87649

Weibull regression -- accelerated failure-time form

No. of subjects      =          258                 Number of obs   =       258
No. of failures      =          258
Time at risk         =        90494
                                                    Wald chi2(23)   =    260.57
Log pseudolikelihood =   -418.87649                 Prob > chi2     =    0.0000

                          (Std. Err. adjusted for 201 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |  -.2704438   .2053503    -1.32   0.188    -.6729231    .1320354
     firmrev |  -7.10e-07   3.12e-06    -0.23   0.820    -6.83e-06    5.41e-06
    firmempl |  -2.65e-07   1.20e-06    -0.22   0.825    -2.61e-06    2.08e-06
recallbrea~h |   1.747586   .3994999     4.37   0.000     .9645801    2.530591
    reactive |   .0291969   .1595423     0.18   0.855    -.2835002    .3418941
detentbinary |   1.127145   .5740853     1.96   0.050     .0019586    2.252332
  prodperiod |    .002442   .0008878     2.75   0.006      .000702     .004182
  noproducts |   .0077731   .0074582     1.04   0.297    -.0068447     .022391
 cat1_frozen |    1.61618   .4429538     3.65   0.000     .7480069    2.484354
cat2_shelf~e |   1.716419   .4213375     4.07   0.000     .8906128    2.542226
    Pathogen |  -.1327504   .4516687    -0.29   0.769    -1.018005    .7525039
    Regional |   .2510722   .2355685     1.07   0.287    -.2106336    .7127779
    National |  -.0625903   .1952739    -0.32   0.749     -.44532    .3201395
     yr_2009 |   .0356033   .3583767     0.10   0.921    -.6668022    .7380088
     yr_2010 |   .1281624    .384042     0.33   0.739    -.6245461    .8808709
noprodXpro~d |  -4.06e-06   .0000111    -0.37   0.714    -.0000258    .0000177
 regbynoprod |  -.1080529   .1348423    -0.80   0.423     -.372339    .1562331
Natlbynoprod |   .0150573   .0806428     0.19   0.852    -.1429996    .1731142
  DetectXReg |  -.7991718   .5474021    -1.46   0.144     -1.87206    .2737166
 DetectXNatl |  -.0715644   .6143739    -0.12   0.907    -1.275715    1.132586
breadthXpr~d |  -.0022155    .000915    -2.42   0.015    -.0040089   -.0004221
detectionX~d |   .0010179   .0125169     0.08   0.935    -.0235147    .0255506
detectXbre~h |  -.7183836   .4821068    -1.49   0.136    -1.663296    .2265284
       _cons |   2.597077   .4593267     5.65   0.000     1.696814    3.497341
-------------+----------------------------------------------------------------
        /ln_p |   .0279753   .0804035     0.35   0.728    -.1296126    .1855632
-------------+----------------------------------------------------------------
           p |    1.02837   .0826845                      .8784357    1.203896
         1/p |   .9724124   .0781853                      .8306363    1.138387
------------------------------------------------------------------------------

.
```

Hypothesized interactions: H2a: Detection X Number of Products; H2b: Detection X Regional, Detection X National

Higher order terms included as misspecification check: Number of Products X Affected Production Period; Detection X Recall Breadth; Regional X Number of Products, National X Number of Products; Recall Breadth X Affected Period.

Results: See Figure 2B.3. Hypothesized interaction terms are not significant (Detection X Regional is significant at $p<.08$). Retain in model. Additional interactions are not significant except for Recall Breadth X Affected Period. Retain Recall Breadth X Affected Period in model. Detection X Recall Breadth is significant at $p<.07$.

Table 2B.1 Comparison of Models 1a, 1b and 1c for Consistency

Predictor	Model 1a		Model 1b		Model 1c		Conclusion
	Sign	Significance	Sign	Significance	Sign	Significance	
Public	-	Significant	-	Significant	-	Significant at p<.10	Consistent
Firm Revenue	+	Not Significant	+	Not Significant	-	Not Significant	Consistent
Firm Employees	-	Not Significant	-	Not Significant	-	Not Significant	Consistent
Recall Breadth	+	Significant	+	Significant	+	Significant	Consistent
Recall Strategy	+	Not Significant	+	Not Significant	+	Not Significant	Consistent
SCRDC	+	Significant	+	Significant	+	Significant	Consistent
QPM	+	Significant	+	Significant	+	Significant	Consistent
Magnitude	+	Not Significant	+	Not Significant	+	Not Significant	Consistent
Cat1_frozen	+	Significant	+	Significant	+	Significant	Consistent
Cat2_Shelf Stable	+	Significant	+	Significant	+	Significant	Consistent
Pathogen	+	Not Significant	+	Not Significant	-	Not Significant	Consistent
Regional	+	Significant	+	Significant at p<.10	+	Not Significant	Consistent
National	-	Not Significant	-	Not Significant	-	Not significant	Consistent
Yr_2009	-	Significant	-	Not Significant	+	Significant	Consistent
Yr_2010	+	Significant	+	Not Significant	+	Significant	Consistent
SCRDC X Regional	-	Not Significant	-	Significant at p<.07	-	Significant at p<.08	Consistent
Detection X National	-	Not Significant	-	Not Significant	-	Not Significant	Consistent
SCRDC X Magnitude	+	Not Significant	+	Not Significant	+	Not Significant	Consistent
Magnitude X QPM	-	Not Significant	-	Not Significant	-	Not Significant	Consistent
SCRDC X Recall Breadth	+	Not Significant	-	Not Significant	-	Significant at p<.07	Consistent
Regional X Magnitude	-	Significant	-	Not Significant	-	Not Significant	Consistent
National X Magnitude	+	Not Significant	+	Not Significant	+	Not Significant	Consistent
Recall Breadth X QPM	-	Significant	+	Significant	-	Significant	Consistent
Constant	+	Significant	+	Significant	+	Significant	Consistent

.

Figure 2B.4 Output, Model 1b Estimates with Hypothesized & Significant Interactions

```
. streg  public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts   cat1_frozen cat2_shelfstable
>  Pathogen Regional National yr_2009 yr_2010 DetectXReg DetectXNatl  detectionXnoprod breadthXprodperiod,  dist(loglogis
> tic) vce(cluster firmcluster)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -573.88058
Iteration 1:   log pseudolikelihood = -516.16367
Iteration 2:   log pseudolikelihood = -501.93514
Iteration 3:   log pseudolikelihood = -501.84949
Iteration 4:   log pseudolikelihood = -501.84946

Fitting full model:

Iteration 0:   log pseudolikelihood = -501.84946
Iteration 1:   log pseudolikelihood = -468.79292
Iteration 2:   log pseudolikelihood =  -458.0704
Iteration 3:   log pseudolikelihood = -457.82862
Iteration 4:   log pseudolikelihood = -457.82824
Iteration 5:   log pseudolikelihood = -457.82824

Loglogistic regression -- accelerated failure-time form

No. of subjects      =          258                 Number of obs   =       258
No. of failures      =          258
Time at risk         =        90494
                                                    Wald chi2(19)   =    179.52
Log pseudolikelihood =   -457.82824                 Prob > chi2     =    0.0000

                          (Std. Err. adjusted for 201 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |  -.4386474   .3376111    -1.30   0.194    -1.100353    .2230581
     firmrev |   4.31e-06   6.57e-06     0.66   0.512    -8.57e-06    .0000172
    firmempl |  -1.33e-06   1.90e-06    -0.70   0.484    -5.06e-06    2.40e-06
recallbrea~h |   1.537855   .2933666     5.24   0.000     .9628669    2.112843
    reactive |   .0778895   .2068846     0.38   0.707     -.327597    .4833759
detentbinary |   1.304055   .5287892     2.47   0.014     .2676474    2.340463
  prodperiod |   .0025367   .0008902     2.85   0.004      .000792    .0042815
  noproducts |   .0057991   .0055747     1.04   0.298    -.0051271    .0167254
 cat1_frozen |    1.80218   .5540464     3.25   0.001     .7162696    2.888091
cat2_shelf~e |   2.07935   .4206505     4.94   0.000      1.25489    2.903809
     Pathogen |  -.0016344   .4435496    -0.00   0.997    -.8709756    .8677069
     Regional |   .1868613   .3007566     0.62   0.534    -.4026107    .7763333
     National |   .0344735   .2672391     0.13   0.897    -.4893056    .5582525
      yr_2009 |    .187749    .422354     0.44   0.657    -.6400496    1.015548
      yr_2010 |   .0227185   .4429141     0.05   0.959    -.8453772    .8908143
   DetectXReg |  -.8076223   .5445903    -1.48   0.138       -1.875     .259755
  DetectXNatl |  -.5296953   .5743315    -0.92   0.356    -1.655364    .5959737
detectionX~d |  -.0019975   .0141078    -0.14   0.887    -.0296482    .0256532
breadthXpr~d |  -.0024157    .000954    -2.53   0.011    -.0042855    -.000546
        _cons |   1.796384   .6549458     2.74   0.006     .5127143    3.080055
-------------+----------------------------------------------------------------
      /ln_gam |   -.278013   .0992262    -2.80   0.005    -.4724929   -.0835332
-------------+----------------------------------------------------------------
        gamma |   .7572869   .0751427                      .6234461    .9198606
------------------------------------------------------------------------------

.
```

Figure 2B.5 Output, Model 1b Average Marginal Effects

```
. margins, dydx(*)

Average marginal effects                        Number of obs   =        258
Model VCE    : Robust

Expression   : Predicted median _t, predict()
dy/dx w.r.t. : public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen
               cat2_shelfstable Pathogen Regional National yr_2009 yr_2010 DetectXReg DetectXNatl detectionXnoprod
               breadthXprodperiod
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
public	-107.9488	81.77511	-1.32	0.187	-268.225	52.32752
firmrev	.0010613	.0016012	0.66	0.507	-.002077	.0041997
firmempl	-.0003275	.0004692	-0.70	0.485	-.0012472	.0005922
recallbrea~h	378.4577	87.59462	4.32	0.000	206.7754	550.14
reactive	19.16818	50.89443	0.38	0.706	-80.58307	118.9194
detentbinary	320.9209	132.9066	2.41	0.016	60.42882	581.413
prodperiod	.624274	.2328924	2.68	0.007	.1678132	1.080735
noproducts	1.427134	1.385898	1.03	0.303	-1.289175	4.143444
cat1_frozen	443.5068	147.5492	3.01	0.003	154.3157	732.6979
cat2_shelf~e	511.7167	113.4274	4.51	0.000	289.4031	734.0302
Pathogen	-.4022053	109.1544	-0.00	0.997	-214.3409	213.5365
Regional	45.98555	73.80135	0.62	0.533	-98.66244	190.6335
National	8.483733	65.67683	0.13	0.897	-120.2405	137.2079
yr_2009	46.20402	103.9821	0.44	0.657	-157.5971	250.0051
yr_2010	5.590909	108.9298	0.05	0.959	-207.9076	219.0895
DetectXReg	-198.7515	135.0592	-1.47	0.141	-463.4626	65.95972
DetectXNatl	-130.3551	143.0614	-0.91	0.362	-410.7503	150.04
detectionX~d	-.4915684	3.469016	-0.14	0.887	-7.290714	6.307577
breadthXpr~d	-.5944983	.2421476	-2.46	0.014	-1.069099	-.1198978

```
. margins, eyex(firmrev firmempl)

Average marginal effects                        Number of obs   =        258
Model VCE    : Robust

Expression   : Predicted median _t, predict()
ey/ex w.r.t. : firmrev firmempl
```

	ey/ex	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
firmrev	.0176703	.0269269	0.66	0.512	-.0351055	.0704462
firmempl	-.0185647	.026532	-0.70	0.484	-.0705665	.0334371

Figure 2B.6 Output, Model 2 Gamma Frailty

```
. streg  public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable P
> athogen Regional National yr_2009 yr_2010  noprodXprodperiod regbynoprod Natlbynoprod  DetectXReg DetectXNatl breadthXp
> rodperiod  detectionXnoprod detectXbreadth, dist(loglogistic) frailty(gamma)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting llogistic model:

Fitting constant-only model:

Iteration 0:   log likelihood = -613.17391
Iteration 1:   log likelihood = -546.42199
Iteration 2:   log likelihood = -509.12124
Iteration 3:   log likelihood = -503.58912
Iteration 4:   log likelihood = -502.26713
Iteration 5:   log likelihood = -501.94435
Iteration 6:   log likelihood = -501.86832
Iteration 7:   log likelihood = -501.85279
Iteration 8:   log likelihood = -501.85024
Iteration 9:   log likelihood = -501.84963
Iteration 10:  log likelihood =  -501.8495
Iteration 11:  log likelihood = -501.84947

Fitting full model:

Iteration 0:   log likelihood = -526.82609
Iteration 1:   log likelihood = -467.95985
Iteration 2:   log likelihood = -458.61256
Iteration 3:   log likelihood = -457.46036
Iteration 4:   log likelihood = -457.23048
Iteration 5:   log likelihood = -457.17836
Iteration 6:   log likelihood = -457.16695
Iteration 7:   log likelihood = -457.16414
Iteration 8:   log likelihood = -457.16357
Iteration 9:   log likelihood = -457.16344
Iteration 10:  log likelihood = -457.16342
Iteration 11:  log likelihood = -457.16341

Loglogistic regression -- accelerated failure-time form
                       Gamma frailty

No. of subjects =          258                     Number of obs   =       258
No. of failures =          258
Time at risk    =        90494
                                                   LR chi2(23)     =     89.37
Log likelihood  =   -457.16341                     Prob > chi2     =    0.0000

------------------------------------------------------------------------------
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |  -.418532   .3296631    -1.27   0.204    -1.06466    .2275958
     firmrev |  2.70e-06   9.17e-06     0.29   0.768    -.0000153   .0000207
    firmempl |  -9.80e-07  2.72e-06    -0.36   0.719    -6.31e-06   4.35e-06
recallbrea~h |  1.564032   .4071531     3.84   0.000     .7660263   2.362037
    reactive |  .0474988   .2537291     0.19   0.852    -.4498011   .5447988
detentbinary |  1.323002   .6141569     2.15   0.031     .1192762   2.526727
  prodperiod |  .0024306   .0011805     2.06   0.040     .0001168   .0047443
  noproducts |  .0127069   .0131842     0.96   0.335    -.0131337   .0385475
 cat1_frozen |  1.779511   .4521381     3.94   0.000     .8933362   2.665685
cat2_shelf~e |  2.080568   .3845387     5.41   0.000     1.326886    2.83425
     Pathogen |  .0229699   .4561784     0.05   0.960    -.8711235   .9170632
     Regional |  .4101119   .3523478     1.16   0.244     -.280477   1.100701
     National |  .0057838   .2904971     0.02   0.984      -.56358   .5751476
      yr_2009 |  .1612608    .516829     0.31   0.755    -.8517056   1.174227
      yr_2010 |  .0242337   .4944205     0.05   0.961    -.9448126     .99328
noprodXpro~d  |  -4.38e-06  .0000222    -0.20   0.843    -.0000479   .0000391
 regbynoprod  |  -.1983194  .1905304    -1.04   0.298    -.5717522   .1751134
Natlbynoprod  |   .008197   .1295766     0.06   0.950    -.2457684   .2621624
  DetectXReg  |  -.8298591   .666297    -1.25   0.213    -2.135777   .4760589
 DetectXNatl  |  -.4719758   .687932    -0.69   0.493    -1.820298   .8763462
breadthXpr~d  |  -.002311   .0012207    -1.89   0.058    -.0047035   .0000816
detectionX~d  |  .0023809    .024226     0.10   0.922    -.0451012   .0498631
detectXbre~h  |  -.1150699  .7866172    -0.15   0.884    -1.656811   1.426671
        _cons |  1.753339   .6223486     2.82   0.005     .5335585    2.97312
-------------+----------------------------------------------------------------
      /ln_gam |  -.2783928  .0540222    -5.15   0.000    -.3842743   -.1725113
      /ln_the |  -17.70611  803.9214    -0.02   0.982    -1593.363    1557.951
-------------+----------------------------------------------------------------
        gamma |   .7569994  .0408947                      .6809446    .8415488
        theta |  2.04e-08   .0000164                            0           .
------------------------------------------------------------------------------
Likelihood-ratio test of theta=0: chibar2(01) =     0.00 Prob>=chibar2 = 1.000

.
```

Results: Neither Gamma nor Inverse Gaussian frailty specifications are significant. Unobserved heterogeneity is not incorporated and Model 1 is preferred.

Figure 2B.7 Output, Model 2 Inverse Gaussian Frailty

```
. streg  public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable P
> athogen Regional National yr_2009 yr_2010  noprodXprodperiod regbynoprod Natlbynoprod  DetectXReg DetectXNatl breadthXp
> rodperiod  detectionXnoprod detectXbreadth, dist(loglogistic) frailty(invgauss)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting llogistic model:

Fitting constant-only model:

Iteration 0:   log likelihood = -582.41961
Iteration 1:   log likelihood = -516.14263
Iteration 2:   log likelihood =  -505.3142
Iteration 3:   log likelihood =  -502.5178
Iteration 4:   log likelihood = -502.00677
Iteration 5:   log likelihood =  -501.8857
Iteration 6:   log likelihood = -501.85728
Iteration 7:   log likelihood = -501.85111
Iteration 8:   log likelihood = -501.84984
Iteration 9:   log likelihood = -501.84955
Iteration 10:  log likelihood = -501.84948
Iteration 11:  log likelihood = -501.84947

Fitting full model:

Iteration 0:   log likelihood = -506.18742
Iteration 1:   log likelihood = -458.94924
Iteration 2:   log likelihood = -457.28534
Iteration 3:   log likelihood = -457.18625
Iteration 4:   log likelihood = -457.16862
Iteration 5:   log likelihood = -457.16464
Iteration 6:   log likelihood = -457.16366
Iteration 7:   log likelihood = -457.16346
Iteration 8:   log likelihood = -457.16342
Iteration 9:   log likelihood = -457.16341

Loglogistic regression -- accelerated failure-time form
                       Inverse-Gaussian frailty

No. of subjects =          258                     Number of obs   =       258
No. of failures =          258
Time at risk    =        90494
                                                   LR chi2(23)     =     89.37
Log likelihood  =   -457.16341                     Prob > chi2     =    0.0000

------------------------------------------------------------------------------
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |    -.41852   .3296844    -1.27   0.204    -1.06469    .2276495
     firmrev |   2.70e-06   9.17e-06     0.29   0.769    -.0000153    .0000207
    firmempl |  -9.80e-07   2.72e-06    -0.36   0.719    -6.31e-06    4.35e-06
recallbrea~h |   1.564028   .4071793     3.84   0.000     .7659712    2.362085
    reactive |   .0475194   .2537449     0.19   0.851    -.4498114    .5448503
detentbinary |   1.323012   .6141979     2.15   0.031     .1192061    2.526818
  prodperiod |   .0024306   .0011806     2.06   0.040     .0001167    .0047445
  noproducts |   .0127053   .0131853     0.96   0.335    -.0131374    .0385479
 cat1_frozen |   1.779557   .4521637     3.94   0.000     .8933319    2.665781
cat2_shelf~e |   2.080604    .384561     5.41   0.000     1.326878     2.83433
    Pathogen |   .0229819   .4562065     0.05   0.960    -.8711663    .9171302
    Regional |    .410104   .3523689     1.16   0.244    -.2805263    1.100734
    National |   .0057426   .2905146     0.02   0.984    -.5636555    .5751408
     yr_2009 |   .1612671   .5168623     0.31   0.755    -.8517644    1.174299
     yr_2010 |    .024353   .4944523     0.05   0.961    -.9447557    .9934616
noprodXpro~d |  -4.38e-06   .0000222    -0.20   0.843    -.0000479    .0000391
 regbynoprod |   -.198314   .1905423    -1.04   0.298      -.57177    .1751419
Natlbynoprod |   .0082191   .1295854     0.06   0.949    -.2457636    .2622019
  DetectXReg |   -.8299106   .6663413    -1.25   0.213    -2.135916    .4760944
 DetectXNatl |    -.471969    .687976    -0.69   0.493    -1.820377    .8764393
breadthXpr~d |   -.0023109   .0012208    -1.89   0.058    -.0047036    .0000817
detectionX~d |   .0023788   .0242281     0.10   0.922    -.0451074    .0498651
detectXbre~h |   -.1151623    .786673    -0.15   0.884    -1.657013    1.426689
       _cons |   1.753279   .6223869     2.82   0.005     .5334227    2.973134
-------------+----------------------------------------------------------------
    /ln_gam |   -.2783169   .0540246    -5.15   0.000    -.3842031   -.1724307
    /ln_the |   -17.63485   831.2313    -0.02   0.983    -1646.818    1611.549
-------------+----------------------------------------------------------------
      gamma |    .7570569   .0408997                      .6809931    .8416167
      theta |   2.19e-08   .0000182                             0           .
------------------------------------------------------------------------------
Likelihood-ratio test of theta=0: chibar2(01) =     0.00 Prob>=chibar2 = 1.000

.
```

Figure 2B.8 Output, Model 3 Estimates

Model 3 – Log-logistic AFT, Recall Breadth=0 Stata Output

```
streg  public firmrev firmempl reactive detentbinary prodperiod noproducts   cat1_frozen cat2_shelfstable Pathogen Regional
>  National yr_2009 yr_2010 DetectXReg DetectXNatl detectionXnoprod if recallbreadth==0 ,dist(loglogistic) vce(cluster firm
> cluster)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -83.907416
Iteration 1:   log pseudolikelihood = -81.095309
Iteration 2:   log pseudolikelihood = -80.898748
Iteration 3:   log pseudolikelihood = -80.898227
Iteration 4:   log pseudolikelihood = -80.898227

Fitting full model:

Iteration 0:   log pseudolikelihood = -80.898227  (not concave)
Iteration 1:   log pseudolikelihood =  -66.76299
Iteration 2:   log pseudolikelihood = -60.318267
Iteration 3:   log pseudolikelihood = -59.714947
Iteration 4:   log pseudolikelihood = -59.713523
Iteration 5:   log pseudolikelihood = -59.713523

Loglogistic regression -- accelerated failure-time form

No. of subjects      =           48                 Number of obs   =        48
No. of failures      =           48
Time at risk         =         5304
                                                    Wald chi2(17)   =    214.20
Log pseudolikelihood =   -59.713523                 Prob > chi2     =    0.0000

                          (Std. Err. adjusted for 45 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |   .0055115   .8466115     0.01   0.995    -1.653817     1.66484
     firmrev |   .0000332   .0000375     0.88   0.377    -.0000404    .0001068
    firmempl |  -4.13e-06   .0000153    -0.27   0.788    -.0000341    .0000259
    reactive |   .0908258   .3387813     0.27   0.789    -.5731733     .754825
detentbinary |   .3724697   .4059744     0.92   0.359    -.4232255    1.168165
  prodperiod |   .0030842   .0009362     3.29   0.001     .0012493     .004919
  noproducts |   .0092522   .0042262     2.19   0.029     .0009691    .0175354
 cat1_frozen |   2.145696   .6783355     3.16   0.002     .8161829    3.475209
cat2_shelf~e |   1.024279   .4217796     2.43   0.015     .1976064    1.850952
     Pathogen |  -.3162362   .3126884    -1.01   0.312    -.9290943    .2966219
     Regional |  -.2687472    .526347    -0.51   0.610    -1.300368    .7628738
     National |  -.7230232   .3279586    -2.20   0.027     -1.36581   -.0802363
      yr_2009 |   .3552594   .4067716     0.87   0.382    -.4419983    1.152517
      yr_2010 |  -.0196742   .4872886    -0.04   0.968    -.9747423     .935394
   DetectXReg |   .0766883   .6132956     0.13   0.900    -1.125349    1.278726
  DetectXNatl |   .4349917   .7151503     0.61   0.543    -.9666772    1.836661
detectionX~d |   .0107415   .0127656     0.84   0.400    -.0142785    .0357616
        _cons |   2.892053   .3992508     7.24   0.000     2.109535     3.67457
-------------+----------------------------------------------------------------
      /ln_gam |  -.7745146   .1540858    -5.03   0.000    -1.076517    -.472512
-------------+----------------------------------------------------------------
        gamma |   .4609275   .0710224                      .3407803    .6234342
------------------------------------------------------------------------------
```

Figure 2B.9 Output, Model 3 Average Marginal Effects

```
. margins, dydx(*)

Average marginal effects                        Number of obs   =         48
Model VCE    : Robust

Expression   : Predicted median _t, predict()
dy/dx w.r.t. : public firmrev firmempl reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable
               Pathogen Regional National yr_2009 yr_2010 DetectXReg DetectXNatl detectionXnoprod
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
public	.4942939	75.95354	0.01	0.995	-148.3719	149.3605
firmrev	.0029772	.003308	0.90	0.368	-.0035063	.0094607
firmempl	-.0003701	.001372	-0.27	0.787	-.0030592	.0023191
reactive	8.145674	30.40481	0.27	0.789	-51.44666	67.738
detentbinary	33.40477	36.65226	0.91	0.362	-38.43233	105.2419
prodperiod	.2766038	.1121568	2.47	0.014	.0567805	.496427
noproducts	.8297823	.4140056	2.00	0.045	.0183462	1.641218
cat1_frozen	192.4358	77.16229	2.49	0.013	41.20045	343.6711
cat2_shelf~e	91.86201	36.54242	2.51	0.012	20.24019	163.4838
Pathogen	-28.3615	27.91058	-1.02	0.310	-83.06523	26.34223
Regional	-24.10247	47.45521	-0.51	0.612	-117.113	68.90803
National	-64.84401	34.41002	-1.88	0.060	-132.2864	2.598391
yr_2009	31.86128	37.99746	0.84	0.402	-42.61237	106.3349
yr_2010	-1.764467	43.6429	-0.04	0.968	-87.30298	83.77405
DetectXReg	6.877755	55.16717	0.12	0.901	-101.2479	115.0034
DetectXNatl	39.01203	66.83482	0.58	0.559	-91.98181	170.0059
detectionX~d	.9633509	1.14792	0.84	0.401	-1.286531	3.213233

```
. margins, eyex(firmrev firmempl)

Average marginal effects                        Number of obs   =         48
Model VCE    : Robust

Expression   : Predicted median _t, predict()
ey/ex w.r.t. : firmrev firmempl
```

	ey/ex	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
firmrev	.0685544	.0775285	0.88	0.377	-.0833987	.2205076
firmempl	-.0348143	.1292173	-0.27	0.788	-.2880756	.2184471

Figure 2B.10 Output, Model 3 Estimated Without Interactions

```
. streg  public firmrev firmempl reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable Pathogen Regional
>  National yr_2009 yr_2010 if recallbreadth==0, dist(loglogistic) vce(cluster firmcluster)

        failure _d:  1 (meaning all fail)
  analysis time _t:  timetorecall

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -83.907416
Iteration 1:   log pseudolikelihood = -81.095309
Iteration 2:   log pseudolikelihood = -80.898748
Iteration 3:   log pseudolikelihood = -80.898227
Iteration 4:   log pseudolikelihood = -80.898227

Fitting full model:

Iteration 0:   log pseudolikelihood = -80.898227  (not concave)
Iteration 1:   log pseudolikelihood = -67.197676
Iteration 2:   log pseudolikelihood = -60.631914
Iteration 3:   log pseudolikelihood = -60.145306
Iteration 4:   log pseudolikelihood = -60.144075
Iteration 5:   log pseudolikelihood = -60.144075

Loglogistic regression -- accelerated failure-time form

No. of subjects      =           48                 Number of obs   =        48
No. of failures      =           48
Time at risk         =         5304
                                                    Wald chi2(14)   =    140.18
Log pseudolikelihood =   -60.144075                 Prob > chi2     =    0.0000

                          (Std. Err. adjusted for 45 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
          _t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |  -.1014371   .7486238    -0.14   0.892    -1.568713    1.365838
     firmrev |   .0000359     .00004     0.90   0.369    -.0000425    .0001142
    firmempl |  -3.67e-06   .0000159    -0.23   0.817    -.0000348    .0000274
    reactive |   .1316331    .319559     0.41   0.680    -.4946909    .7579572
detentbinary |   .5766707   .4138236     1.39   0.163    -.2344086     1.38775
  prodperiod |   .0029553   .0008827     3.35   0.001     .0012253    .0046854
  noproducts |   .0109142   .0036597     2.98   0.003     .0037414     .018087
 cat1_frozen |    2.18034   .7288789     2.99   0.003      .751764    3.608917
cat2_shelf~e |   1.099083   .4021486     2.73   0.006     .3108867     1.88728
     Pathogen |  -.2997793   .2933239    -1.02   0.307    -.8746836     .275125
     Regional |  -.1984133    .439051    -0.45   0.651    -1.058938    .6621109
     National |  -.5391199   .4347696    -1.24   0.215    -1.391253    .3130128
      yr_2009 |   .3064831    .39035     0.79   0.432    -.4585889    1.071555
      yr_2010 |   .0182859   .4953179     0.04   0.971    -.9525192    .9890911
        _cons |   2.739497   .4465605     6.13   0.000     1.864255     3.61474
-------------+----------------------------------------------------------------
      /ln_gam |  -.7577247   .1393205    -5.44   0.000    -1.030788   -.4846616
-------------+----------------------------------------------------------------
        gamma |   .4687317   .0653039                      .3567258    .6159056
------------------------------------------------------------------------------
```

Multicollinearity Check

In order to avoid potentially excessive inflation of standard errors due to multicollinearity among the predictor variables, we test a linear model for variance inflation. Using a variance inflation factor (VIF) of less than 10 or a tolerance (1/VIF) of less than 0.1, we find no evidence of excessive multicollinearity in Model 1b or Model 3.

Figure 2B.11 Output, Model 1b Multicollinearity Check

```
. regress timetorecall public firmrev firmempl recallbreadth reactive detentbinary prodperiod noproducts cat1_frozen cat2
> _shelfstable Pathogen Regional National yr_2009 yr_2010  noprodXprodperiod regbynoprod Natlbynoprod  DetectXReg DetectX
> Natl detectionXnoprod detectXbreadth, cluster(firmcluster)

Linear regression                                     Number of obs =     258
                                                      F( 22,   200) =    7.88
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.1931
                                                      Root MSE      =  302.64

                                    (Std. Err. adjusted for 201 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
timetorecall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |  -108.0758   55.04034    -1.96   0.051    -216.6096    .4580902
     firmrev |   .0002467    .001292     0.19   0.849    -.0023009    .0027943
    firmempl |  -.0001451   .0004526    -0.32   0.749    -.0010376    .0007473
recallbrea~h |   237.5881   59.93876     3.96   0.000     119.3951    355.7811
    reactive |  -1.257054   49.82181    -0.03   0.980    -99.50049    96.98638
detentbinary |   92.40993   82.96326     1.11   0.267      -71.185    256.0049
  prodperiod |     .07089   .0936036     0.76   0.450    -.1136867    .2554666
  noproducts |     .22862   2.789562     0.08   0.935    -5.272106    5.729346
 cat1_frozen |   164.4753   81.71949     2.01   0.045     3.332942    325.6176
cat2_shelf~e |   244.6637   50.36914     4.86   0.000      145.341    343.9864
    Pathogen |   65.06117   66.38328     0.98   0.328    -65.83976    195.9621
    Regional |   52.14509   100.1605     0.52   0.603    -145.3611    249.6512
    National |  -45.65813   76.36621    -0.60   0.551    -196.2444    104.9281
     yr_2009 |  -14.51589   59.42215    -0.24   0.807    -131.6902    102.6584
     yr_2010 |   2.138258   61.87279     0.03   0.972    -119.8685     124.145
noprodXpro~d |   .0009566   .0048197     0.20   0.843    -.0085473    .0104604
 regbynoprod |  -18.9369   53.22967    -0.36   0.722    -123.9003    86.02649
Natlbynoprod |   22.49533   29.44564     0.76   0.446    -35.56841    80.55908
  DetectXReg |  -36.90156   105.7534    -0.35   0.728    -245.4362    171.6331
 DetectXNatl |   93.74887   114.3089     0.82   0.413    -131.6563    319.1541
detectionX~d |  -2.64471   3.077076    -0.86   0.391    -8.712384    3.422965
detectXbre~h |  -2.949961   110.5108    -0.03   0.979    -220.8658    214.9659
       _cons |  -113.1491   91.19802    -1.24   0.216    -292.9822     66.6839
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
detentbinary |      6.64    0.150555
     yr_2009 |      4.74    0.211104
recallbrea~h |      4.07    0.245642
 regbynoprod |      3.99    0.250384
    Regional |      3.70    0.270369
cat2_shelf~e |      3.54    0.282157
     firmrev |      3.51    0.285007
  noproducts |      3.51    0.285063
    firmempl |      3.34    0.298999
  DetectXReg |      3.15    0.317617
    National |      3.12    0.320813
Natlbynoprod |      3.10    0.323088
 cat1_frozen |      2.89    0.346073
    Pathogen |      2.71    0.369500
 DetectXNatl |      2.58    0.386894
noprodXpro~d |      2.17    0.461157
     yr_2010 |      1.95    0.511959
      public |      1.87    0.533827
detectionX~d |      1.81    0.552817
  prodperiod |      1.59    0.629271
detectXbre~h |      1.42    0.703574
    reactive |      1.19    0.839405
-------------+----------------------
    Mean VIF |      3.03

.
```

Figure 2B.12 Output, Model 3 Multicollinearity Check

```
. regress timetorecall public firmrev firmempl reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable Pat
> hogen Regional National yr_2009 yr_2010 noprodXprodperiod regbynoprod Natlbynoprod DetectXReg DetectXNatl  detectionXnopr
> od if recallbreadth==0, cluster (firmcluster)

Linear regression                               Number of obs =      48
                                                F( 20,    44) =    7.15
                                                Prob > F      =  0.0000
                                                R-squared     =  0.7081
                                                Root MSE      =   99.59

                                  (Std. Err. adjusted for 45 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
timetorecall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |    69.67727   54.78716     1.27   0.210      -40.739    180.0935
     firmrev |   -.0067717    .006179    -1.10   0.279    -.0192247    .0056814
    firmempl |    .0027464   .0020103     1.37   0.179    -.0013051    .0067978
    reactive |    42.46192   46.41534     0.91   0.365    -51.08205    136.0059
detentbinary |   -46.75614   40.94244    -1.14   0.260    -129.2702    35.75792
  prodperiod |    .4458118   .2809858     1.59   0.120    -.1204778    1.012101
  noproducts |    5.123869   1.573785     3.26   0.002     1.952115    8.295624
 cat1_frozen |    220.4318   75.04498     2.94   0.005     69.18857     371.675
cat2_shelf~e |    19.56158   31.44824     0.62   0.537    -43.81817    82.94134
     Pathogen |    22.96281    44.6152     0.51   0.609    -66.95321    112.8788
     Regional |    23.58726   66.60766     0.35   0.725    -110.6517    157.8262
     National |   -32.96084   43.25282    -0.76   0.450    -120.1312    54.20948
      yr_2009 |   -30.76605   47.95215    -0.64   0.524    -127.4073    65.87517
      yr_2010 |   -12.47665   49.10257    -0.25   0.801    -111.4364    86.48308
noprodXpro~d |    .0236162   .0600458     0.39   0.696    -.0973981    .1446305
 regbynoprod |   -88.86661   36.65101    -2.42   0.019    -162.7319   -15.00135
Natlbynoprod |   -65.33483   37.95169    -1.72   0.092    -141.8214    11.15177
  DetectXReg |    125.0521   87.61368     1.43   0.161    -51.52171    301.6258
 DetectXNatl |    113.1902   68.77179     1.65   0.107     -25.4102    251.7907
detectionX~d |   -.8325769   3.006134    -0.28   0.783    -6.891041    5.225887
       _cons |    15.17917    39.6613     0.38   0.704    -64.75293    95.11128
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
    firmempl |      8.72    0.114622
     firmrev |      7.82    0.127913
    National |      7.37    0.135619
  DetectXReg |      7.03    0.142300
    Regional |      6.87    0.145525
 regbynoprod |      6.64    0.150584
detentbinary |      6.21    0.160950
noprodXpro~d |      5.76    0.173473
 DetectXNatl |      5.47    0.182729
Natlbynoprod |      4.27    0.233956
  noproducts |      4.01    0.249254
detectionX~d |      3.78    0.264355
  prodperiod |      2.98    0.335717
      public |      2.40    0.417488
    Pathogen |      2.27    0.440003
     yr_2009 |      2.07    0.483446
     yr_2010 |      1.95    0.512193
cat2_shelf~e |      1.93    0.517100
    reactive |      1.76    0.567523
 cat1_frozen |      1.68    0.594900
-------------+----------------------
    Mean VIF |      4.55

.
```

Figure 2B.13 Output, Model 3 Without Interactions Multicollinearity Check

```
. regress timetorecall public firmrev firmempl reactive detentbinary prodperiod noproducts cat1_frozen cat2_shelfstable Pat
> hogen Regional National yr_2009 yr_2010 if recallbreadth==0, cluster (firmcluster)

Linear regression                               Number of obs =      48
                                                F( 14,    44) =    3.55
                                                Prob > F      =  0.0006
                                                R-squared     =  0.5779
                                                Root MSE      =  108.33

                                  (Std. Err. adjusted for 45 clusters in firmcluster)
------------------------------------------------------------------------------
             |               Robust
timetorecall |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      public |   67.24404   62.99791     1.07   0.292    -59.71991     194.208
     firmrev |  -.0034452   .0066789    -0.52   0.609    -.0169056    .0100151
    firmempl |   .0017262   .0023062     0.75   0.458    -.0029217    .0063741
    reactive |   31.40179   34.53904     0.91   0.368    -38.20707    101.0107
detentbinary |    45.1678   33.59368     1.34   0.186    -22.53582    112.8714
  prodperiod |   .4534164   .2274918     1.99   0.052    -.0050631    .9118959
  noproducts |   1.069738   .6060481     1.77   0.084    -.1516722    2.291147
 cat1_frozen |   210.9417   86.27126     2.45   0.019     37.07341      384.81
cat2_shelf~e |   39.45472   30.35269     1.30   0.200    -21.71711    100.6266
    Pathogen |  -13.63888   37.81564    -0.36   0.720     -89.8513    62.57353
    Regional |   10.81511   43.09993     0.25   0.803    -76.04708    97.67731
    National |  -23.86519    43.0145    -0.55   0.582    -110.5552    62.82484
     yr_2009 |  -10.87949    46.3849    -0.23   0.816    -104.3621    82.60312
     yr_2010 |  -12.84213   44.13347    -0.29   0.772    -101.7873    76.10304
       _cons |  -18.66388   49.69564    -0.38   0.709    -118.8189    81.49109
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
    firmempl |      7.91    0.126484
     firmrev |      6.72    0.148846
    National |      2.34    0.428246
      public |      2.11    0.474822
    Regional |      2.09    0.478918
     yr_2009 |      1.86    0.536483
    Pathogen |      1.80    0.554571
     yr_2010 |      1.68    0.596001
detentbinary |      1.68    0.596910
cat2_shelf~e |      1.67    0.599211
 cat1_frozen |      1.54    0.650848
  prodperiod |      1.36    0.734063
    reactive |      1.36    0.735934
  noproducts |      1.22    0.819883
-------------+----------------------
    Mean VIF |      2.52
```

APPENDIX 3A
ESSAY 2 CONSTRUCT DEFINITIONS AND SAMPLE DESCRIPTIVES

Table 3A.1 Constructs and Operational Definitions

Construct	Definition	Citations
Purchase Risk	***Purchase risk*** consists of two components: 1) the severity of the loss (physical, financial, etc.) associated with a potential negative outcome and 2) the likelihood that the outcome will be negative.	Bettman, 1973; Gurhan-Canli & Batra, 2004; Mitchell, 1999; Siomokos & Kurzbad, 1994; Taylor, 1974
Locus	An ***internal locus*** occurs when a defect that causes a product recall happens inside the manufacturing firm.	Folkes, 1984; Folkes 1988; Klein & Dawar, 2004
	An ***external locus*** occurs when a defect that causes a product recall happens outside the manufacturing firm. In other words, the defect is because of something that happened at a supplier or retailer, or some other entity other than the manufacturer.	
Stability (Corrective Action)	***Stability*** relates to the permanence of the cause of the defect. A stable defect is one that a consumer could reasonably expect to occur again in the future. An unstable defect is one that the consumer can reasonably expect will not occur again in the future. Stability is operationalized by providing (unstable) or withholding (stable) a corrective action in the recall announcement.	Folkes, 1984
Controllability	A ***controllable*** defect is one in which the supplier or manufacturer has volitional control over the circumstances that allowed the defect to happen or to pass on to the consumer. An ***uncontrollable*** defect is one in which the manufacturer or supplier does not have volitional control over the circumstances which cause the defect to happen or pass on to the consumer.	Folkes, 1984; Folkes 1988; Dawar & Klein, 2006
Purchase Dissatisfaction	Purchase dissatisfaction occurs when a consumer's expectations about a product's performance are not met.	Oliver, 1993; Oliver & DeSarbo, 1988; Oliver & Swan, 1989; Westbrook & Oliver, 1991

Construct	Definition	Citations
Repurchase Intent	***Repurchase Intent*** is an individual's intent regarding purchasing a product that they have already purchased at some time in the past. In other words, the individual has experience with buying and using the product, and ***Repurchase Intent*** has to do with whether they would buy it again.	Siomokos & Kurzbad, 1994
Recall Satisfaction	The degree to which a consumer's expectations regarding the handling of a product recall are met by the firm announcing the recall	Jolly & Mowen, 1985; Laufer, 2002; Mowen, Jolly & Nickell, 1981
Recall Responsibility	The degree to which the consumer holds the supplier (supplier responsibility) or the firm conducting the recall (manufacturer responsibility) responsible for the recall event.	Laufer, 2002; Laufer et al, 2005
Shared Responsibility	The degree to which the consumer believe that the supplier and the firm conducting the recall share responsibility for the recall event.	

Supplementary Sample Descriptives

Table 3A.2 Treatment Assignment

Scenarios

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Scenario 1 - Text 1	45	25.0	25.0	25.0
	Scenario 2 - Text 1	41	22.8	22.8	47.8
	Scenario 3 - Text 1	50	27.8	27.8	75.6
	Scenario 4 - Text 1	44	24.4	24.4	100.0
	Total	180	100.0	100.0	

Table 3A.3 Demographics - Gender

What is your gender?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	63	35.0	35.0	35.0
	Male	117	65.0	65.0	100.0
	Total	180	100.0	100.0	

Table 3A.4 Demographics – Age

Which category below includes your age?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20 or younger	12	6.7	6.7	6.7
	21-29	98	54.4	54.4	61.1
	30-39	39	21.7	21.7	82.8
	40-49	18	10.0	10.0	92.8
	50-59	9	5.0	5.0	97.8
	60-69	4	2.2	2.2	100.0
	Total	180	100.0	100.0	

Table 3A.5 Demographics - Education

What is your highest level of education completed?

Please mark the most appropriate choice.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High School	5	2.8	2.8	2.8
	Some College	79	43.9	43.9	46.7
	Bachelor's Degree	27	15.0	15.0	61.7
	Some Graduate School	40	22.2	22.2	83.9
	Master's Degree	22	12.2	12.2	96.1
	Doctorate	7	3.9	3.9	100.0
	Total	180	100.0	100.0	

APPENDIX 3B
ESSAY 2 MEASUREMENT ITEM AND VIGNETTE DEVELOPMENT AND MANIPULATION CHECKS

Preliminary Vignette Exercise

The following four in-class "exercises" were distributed to a MBA class at Clemson University. Two scenarios deal with food recalls and two deal with pharmaceutical recalls. Approximately 15 minutes were allowed for responses. Fifteen responses were collected; the responses were evaluated qualitatively to determine if the scenarios had face validity and were used as the basis for developing the scenarios for the sorting exercise. Although vignettes dealing with pharmaceutical products were included in this exercise, the pilot study reported here deals with a single food product.

Food 1

Please read the scenario below and answer the questions that follow. There are no right or wrong answers.

On your way home from work, you do some grocery shopping at a local store. One of the items you purchase is a box of individually wrapped nutrition bars. After arriving home, you check your email and a news headline related to a product recall catches your eye. You click on the headline and are redirected to the following press release:

Nutramill Announces Nationwide Voluntary Nutrition Bar Recall

Contact: *Consumer - 555-310-1479*

FOR IMMEDIATE RELEASE *– February 27, 2012 – Nutramill has initiated a voluntary recall of all Nutramill Nutrition Bars manufactured using wheat flour imported from Zhou Ying Development Co. Ltd., because they have the potential to be contaminated with* ***Salmonella****, an organism which can cause serious and sometimes fatal infections in young children, frail or elderly people, and others with weakened immune systems. Healthy persons infected with* ***Salmonella*** *often experience fever, diarrhea (which may be bloody), nausea, vomiting and abdominal pain. In rare circumstances, infection with* ***Salmonella*** *can result in the organism getting into the bloodstream and producing more severe illnesses such as arterial infections (i.e., infected aneurysms), endocarditis and arthritis.*

Twenty-one illnesses have been reported to date in connection with this product.

The Nutramill Nutrition Bars are sold individually and in boxes of six individually wrapped bars at retailers nationwide. The batch numbers, located on the outside wrapper of each bar, included in the recall are 20061006, 20061027, 20061101, 20061108, 20061122, 20061126, 20061201, 20061202, 20061203, and 20061204. Each batch was manufactured using wheat flour supplied by Zhou Ying Development Co. Ltd. The supplier's certificate of analysis information indicated that testing for salmonella was negative.

On February 26th, the FDA announced they had found salmonella in samples of the Nutramill Nutrition Bars.

Nutramill is extremely concerned about the quality and safety of all of its products. The company is particularly troubled that the certificates of analysis provided by the above-named supplier did not report the presence of salmonella.

Nutramill wants to ensure its products are safe. Consequently, in addition to its ongoing cooperation with the FDA, Nutramill will be conducting its own independent, analytical tests of wheat flour from all of its suppliers.

After reading the press release you check the label of the nutrition bars you have just purchased and find that it is Nutramills brand packaged in a box of six individually wrapped bars. The lot number in the press release matches that listed on the box.

Food 2

Please read the scenario below and answer the questions that follow. There are no right or wrong answers.

On your way home from work, you do some grocery shopping at a local store. One of the items you purchase is a box of individually wrapped nutrition bars. After arriving home, you check your email and a news headline related to a product recall catches your eye. You click on the headline and are redirected to the following press release:

Nutramill Announces Nationwide Voluntary Nutrition Bar Recall

Contact: *Consumer - 555-310-1479*

FOR IMMEDIATE RELEASE *– February 27, 2012 – Nutramill has initiated a voluntary recall of all Nutramill Nutrition Bars because they have the potential to be contaminated with* ***Salmonella****, an organism which can cause serious and sometimes fatal infections in young children, frail or elderly people, and others with weakened immune systems. Healthy persons infected with* ***Salmonella*** *often experience fever, diarrhea (which may be bloody), nausea, vomiting and abdominal pain. In rare circumstances, infection with* ***Salmonella*** *can result in the organism getting into the bloodstream and producing more severe illnesses such as arterial infections (i.e., infected aneurysms), endocarditis and arthritis.*

Twenty-one illnesses have been reported to date in connection with this product.

The Nutramill Nutrition Bars are sold individually and in boxes of six individually wrapped bars at retailers nationwide. The batch numbers, located on the outside wrapper of each bar, included in the recall are 20061006, 20061027, 20061101, 20061108, 20061122, 20061126, 20061201, 20061202, 20061203, and 20061204.

On February 26th, the FDA announced they had found salmonella in samples of Nutramill Nutrition Bars.

Nutramill is extremely concerned about the quality and safety of all of its products. Nutramill wants to ensure its products are safe. Consequently, in addition to its ongoing cooperation with the FDA, Nutramill will be conducting its own independent, analytical tests of finished products prior to distribution.

Questions for Food 1 & 2

Please answer the following questions based on the scenario you just read. There are no right or wrong answers.

1. Whom do you hold responsible for the defect that has caused the recall of the nutrition bars?

2. What, if any, additional information would you like to see in the press release?

3. What will you do with the nutrition bars you have purchased?

4. Whom do you hold responsible for the safety of the nutrition bars?

5. If this were a real situation, how much would this recall influence your future purchase decisions regarding nutrition bars? (Circle one)

    a. NEGATIVE influence – less likely to purchase this brand again

    b. NO INFLUENCE on future purchases one way or the other

    c. POSITIVE influence – more likely to purchase this brand again

6. How do you feel about the way Nutramill has handled the recall? Why?

Pharma 1

Please read the scenario below and answer the questions that follow. There are no right or wrong answers.

On your way home from work, you decide to stop by a local pharmacy to buy cough and cold medicine. You have been feeling a cold coming on for the past few days and want to get relief from the symptoms. After arriving home, you check your email and a news headline related to a product recall catches your eye. You click on the headline and are redirected to the following press release:

Sierra Pharmaceuticals Initiates a Nationwide Voluntary Recall of Sierra Cough & Cold 12-Hour Relief Syrup, Lot Number 3J6274B

Contact: *Consumer - 555-233-8536*

FOR IMMEDIATE RELEASE *– February 27, 2012 – Sierra Pharmaceuticals Inc. has initiated a voluntary recall of one lot of 4 ounce bottles of Sierra Cough & Cold 12-Hour Relief Syrup, after being notified by its supplier, Stillwater Laboratories, that a manufacturing error had affected the product. Due to this manufacturing error, acetaminophen, an active ingredient in the cough and cold syrup, may be present in quantities greater than what is specified on the product label. Bottles of the cough and cold syrup are sold to consumers via pharmacies and other retail outlets. The lot number affected in the U.S. is 3J6274B with an expiry date of September 30, 2012. The lot number appears on the bottom of the bottle.*

Sierra Cough & Cold 12-Hour Relief is used to treat the symptoms of the cold virus. A decrease of active ingredient could reduce the efficacy of the syrup. An increase in the active ingredient could result in over dosage of acetaminophen which may result in liver toxicity, kidney damage, and blood disorders.

Twenty-one incidents of acetaminophen over dosage have been reported in connection to this product.

Patients who may have the affected syrup should discard the product or return it to the retailer for a full refund.

Sierra Pharmaceuticals is committed to ensuring patient safety and is working to resolve this issue quickly and appropriately. The company has notified the U.S. Food and Drug Administration (FDA), and will issue recall communications to all distributors and retail outlets involved.

Any adverse reactions may be reported to the FDA's MedWatch Program by fax at 1-800-FDA-0178, by mail at MedWatch, HF-2, FDA, 5600 Fishers Lane, Rockville, MD 20852-9787, or on the MedWatch website at www.fda.gov[1].

After reading the press release you check the label of the cough and cold medicine you have just purchased and find that it is Sierra Pharmaceuticals brand Cough and Cold 12-Hour Relief Syrup, in a 4 ounce container. The lot number in the press release matches that listed on the bottle.

Pharma 2

Please read the scenario below and answer the questions that follow. There are no right or wrong answers.

On your way home from work, you decide to stop by a local pharmacy to buy cough and cold medicine. You have been feeling a cold coming on for the past few days and want to get relief from the symptoms. After arriving home, you check your email and a news headline related to a product recall catches your eye. You click on the headline and are redirected to the following press release:

Sierra Pharmaceuticals Initiates a Nationwide Voluntary Recall of Sierra Cough & Cold 12-Hour Relief Syrup, Lot Number 3J6274B

Contact: *Consumer - 555-233-8536*

FOR IMMEDIATE RELEASE *– February 27, 2012 – Sierra Pharmaceuticals Inc. has initiated a voluntary recall of one lot of 4 ounce bottles of Sierra Cough & Cold 12-Hour Relief Syrup. Bottles of the cough and cold syrup are sold to consumers via pharmacies and other retail outlets. The lot number affected in the U.S. is 3J6274B with an expiry date of September 30, 2012. The lot number appears on the bottom of the bottle. The recall is being conducted after testing indicated that acetaminophen, an active ingredient in the cough and cold syrup, may be present in quantities greater than what is specified on the product label.*

Sierra Cough & Cold 12-Hour Relief is used to treat the symptoms of the cold virus. A decrease of active ingredient could reduce the efficacy of the syrup. An increase in the active ingredient could result in over dosage of acetaminophen which may result in liver toxicity, kidney damage, and blood disorders.

Twenty-one incidents of acetaminophen over dosage have been reported in connection to this product.

Patients who may have the affected syrup should discard the product or return it to the retailer for a full refund.

Sierra Pharmaceuticals is committed to ensuring patient safety and is working to resolve this issue quickly and appropriately. The company has notified the U.S. Food and Drug Administration (FDA), and will issue recall communications to all distributors and retail outlets involved.

Any adverse reactions may be reported to the FDA's MedWatch Program by fax at 1-800-FDA-0178, by mail at MedWatch, HF-2, FDA, 5600 Fishers Lane, Rockville, MD 20852-9787, or on the MedWatch website at www.fda.gov[1].

After reading the press release you check the label of the cough and cold medicine you have just purchased and find that it is Sierra Pharmaceuticals brand Cough and Cold 12-Hour Relief Syrup, in a 4 ounce container. The lot number in the press release matches that listed on the bottle.

Questions for Pharma 1 & 2

Please answer the following questions based on the scenario you just read. There are no right or wrong answers.

1. Whom do you hold responsible for the defect that has caused the recall of the cough and cold syrup?

2. What, if any, additional information would you like to see in the press release?

3. What will you do with the cough and cold syrup you have purchased?

4. Whom do you hold responsible for the safety of the cough and cold syrup?

5. If this were a real situation, how much would this recall influence your future purchase decision regarding cough and cold syrup? (Circle one)

    a. NEGATIVE influence – less likely to purchase this brand again

    b. NO INFLUENCE on future purchases one way or the other

    c. POSITIVE influence – more likely to purchase this brand again

6. How do you feel about the way Sierra Pharmaceuticals has handled the recall? Why?

Vignette Exercise Findings

General in-class feedback indicated that the vignettes, which were patterned after the format dictated by FDA guidance for product recalls, and the situation described were considered by the subjects to be realistic. As expected, the reactions to the scenario indicated a negative influence or no influence on repurchase intent (of 15 responses, 10 indicated a negative influence, 5 indicated no influence), which seemed to be related to the degree of satisfaction the subject felt with respect to the content and tone of the recall announcement.

The use of the word "voluntary" in the recall announcement, which is typical for FDA-regulated product recalls which are typically not legal enforcement actions, triggered, for some respondents, a positive feeling towards the recalling firm. Noting this, we determined that we would exclude the use of the word "voluntary" from the final experimental scenarios to remove the potential for a spurious attribution of responsible action on the part of the recalling firm. Since, in our investigation of FDA-regulated recalls over the period of 2008-2010 we found no more than a handful of recall announcements which were involuntary, and carried out by the FDA (among over a thousand voluntary recalls) we believe this departure from realism to be justified in the interests of maintaining internal validity of the experiment.

Interestingly, even in the manipulations where the recalling firm attributed the failure to a supplier's actions, the respondents indicated that they held the recalling firm primarily responsible for the product's safety. In some cases, respondents indicated that they consider governmental agencies, such as the FDA to be secondarily responsible for

product safety. We considered this to provide an intriguing clue to the way consumers may respond when firm's attempt to deflect blame for a defect on to their suppliers.

A number of respondents indicated that they would like to have more information from the recalling firm, including the root cause of the defect, corrective action for the defect, symptoms of illness, and more information about what to do if the product had been recently consumed.

Vignette Pre-Test

The following food product recall scenario was administered to a group of undergraduate management students at Clemson University. Students received extra credit for completing the exercise. The exercise was administered online; 17 responses were collected. The purpose of this pilot was to ensure face validity, readability, confirm the amount of time the exercise required, and to test participant comprehension of the manipulation. Results from this pilot were used, including feedback from participants, to design the experimental vignettes for the pilot study reported in this dissertation.

In general, comprehension was excellent. One clearly inconsistent statement was made regarding the circumstances described in the announcement; results of this item were unambiguously negative. Response to manipulations of locus (external), controllability (controllable), and corrective action (unstable – corrective action provided) were consistent with the information presented. Results of items related to perceived risk were relatively high, consistent with the product failure scenario provided. Repurchase intent, recall satisfaction, and responsibility were directionally consistent with our expectations based on the cues provided. One item – dealing with whether or not the

product was expired at the time of the recall announcement (it was not) appeared to be confusing to participants.

Participants estimated that the exercise took between 10 and 20 minutes on average. Free text comments regarding clarity ranged from "the entire survey was easy to understand" to a few comments explaining that blame was perceived to be shared by the buyer and supplier in this scenario.

The text of the pre-test vignette is provided below. Table 4b.1 below summarizes the results of the participant responses.

On your way home from work you do some grocery shopping at a local store. One of the items you purchase is a frozen cheese pizza. After arriving home, you check you email and a news headline related to a product recall catches you eye. You click on the headline and are redirected to the following press release:

Chef Milo Announces Nationwide Recall of Frozen Cheese Pizza

FOR IMMEDIATE RELEASE: April 9, 2012 – Chef Milo Corporation has initiated a recall of all frozen cheese pizza manufactured using flour imported from Zhou Ying Development Co., Ltd, because they have the potential to be contaminated with Salmonella, an organism which can cause serious and sometimes fatal infections in young children, frail, or elderly people, and others with weakened immune systems. Healthy persons infected with Salmonella often experience fever, diarrhea (which may be bloody), nausea, vomiting, and abdominal pain. In rare circumstances, infection with Salmonella can result in the organism getting into the bloodstream and producing more severe illnesses such as arterial infections (i.e., infected aneurysms), endocarditis and arthritis.

One hundred and twenty-one illnesses have been reported to date in connection with this product.

The Chef Milo frozen cheese pizzas are sold individually nationwide. The batch numbers, located on the outside packaging of each pizza, included in the recall are 20061006 with an expiration date of September 30, 2012. Each batch was manufactured using flour supplied by Zhou Ying Development Co., Ltd. The supplier's certificate of analysis information indicated that testing for salmonella was negative.

On April 8th, the FDA announced they had found salmonella in samples of frozen pizzas collected during a routine inspection. Subsequent investigation revealed that the source of contamination was the flour supplied by Zhou Ying Development Co., Ltd.

Chef Milo is extremely concerned about the quality and safety of all of its products. The company is particularly troubled that the certificates of analysis provided by the above-named supplier did not report the presence of salmonella.

Consumers who have the affected pizzas should discard the product or return it to the retailer for a full refund.

Chef Milo wants to ensure its products are safe. Consequently, in addition to its ongoing cooperation with the FDA, Chef Milo will be conducting its own independent, analytical tests of flour from all of its suppliers.

After reading the press release you check the label of the frozen pizza you have just purchased and find that it is a Chef Milo brand frozen cheese pizza. The batch number in the press release matches that listed on the box.

Table 3B.1 Vignette Pre-Test Items, Means, Standard Deviations and Interpretation of Results[1]

Item	Mean	Std Dev	Interpretation
Salmonella can cause a variety of health problems, some of them very serious.	1.29	.59	Salmonella warning appears to be taken seriously.
The product was recalled because the manufacturer found out that the distributor's refrigeration failed, causing bacteria to grow and the product to spoil.	4.19	.83	Comprehension good – this is not what was described in the announcement.
I blame the Chef Milo Corporation for this recall.	3.24	.75	Consistent with external locus.
I could get sick from consuming food that has quality issues.	1.35	.61	Perceived risk – high, consistent with product failure & hazard warnings.
This product recall could have been prevented by Zhou Ying Development Co. Ltd.	1.82	.64	Consistent with supplier involvement & controllability.
I feel like this product could be hazardous.	1.53	.72	Perceived risk – high, consistent with product failure & hazard warnings.
The Chef Milo Corporation recalled this product prior to its stated expiration date.	3.12	1.65	Confusion regarding expiration and date of recall.
I blame the supplier of the flour for this recall.	1.76	.66	Consistent with supplier involvement & controllability.
I would probably eat this pizza anyway.	4.47	.87	Perceived risk – high, consistent with product failure & hazard warnings.
In general, I'm worried about the quality of the food supply.	2.13	.96	Perceived risk – high, consistent with product failure & hazard warnings.
A number of people got sick because of this problem.	2.67	1.3	Consistent with announcement and ambiguous wording of item.
I believe that the responsibility for this problem is shared by Chef Milo and their supplier.	2.18	1.07	Consistent with supplier involvement & controllability
I would definitely think twice before buying a Chef Milo product in the future.	2.00	.71	Repurchase intent – consistent with product failure

Item	Mean	Std Dev	Interpretation
I believe that the Chef Milo Corporation could have done more to prevent this problem.	2.6	.74	Consistent with free text statements – that Chef Milo should have done more testing.
This product recall could have been prevented by the Chef Milo Corporation.	2.38	.81	
Based on this recall I would be less likely to purchase Chef Milo brands in the future.	2.18	.81	Repurchase intent – consistent with product failure
This particular problem is unlikely to happen again in the future.	2.89	.88	Consistent with announcement & corrective action.
I feel like it is more likely than ever that the food I buy might have something wrong with it.	3.53	.87	Perceived risk does not appear to extend across all food products.
Now that I know the frozen pizza was recalled, I feel like eating it might be unsafe.	2.24	1.48	Perceived risk – high, consistent with product failure & hazard warnings.
This product recall was triggered by testing conducted by the FDA.	2.41	1.46	Consistent with announcement.
The Chef Milo Corporation seems to have handled this problem responsibly.	2.06	.67	Recall satisfaction - consistent with corrective action, supportive statements of concern.
Please estimate how much time you think reading & completing this survey has taken you.	4.24	.56	Between 10 and 20 minutes on average.
If you have any comments about the wording of the scenario or questions, or if you find any of the questions or information provided confusing, please note it below.	NA	NA	

Note 1: All scales are 1 to 5 agreement 1= Very strongly agree and 5= Very strongly disagree except for time estimate, which is a 5 point scale anchored by ">40 minutes" and "<10 minutes", in 10 minute increments and the open-ended question for comments and clarifications which was presented at the bottom of each survey page.

Item Sorting

Q-sort exercises were conducted in undergraduate management classes at Clemson University. Students received extra credit for completing the sorting exercise. The exercise was administered online. To minimize the length of the sorting exercise, items were broken up into three sorting groups. Some of the sorted constructs were not included in the final design and ultimately several constructs were added. In order to detect unusable or inattentive responses, the sorts included unrelated items which would necessarily be correctly classified as "Not Applicable". These items included unrelated phrases such as "I would like to live off campus" and "Clemson colors are purple and orange". Responses which did not correctly classify these obviously unrelated items were not used in the tentative item validation. See main text for details.

Table 3B.2 Q-Sort Set 1 Items[1]

Constructs	Items
Internal Locus (Manipulated Factor)	The company recalled the product because they detected salmonella in their finished goods.
	The company recalled the product because they added the wrong amount of an ingredient during manufacturing.
	The company recalled a product after it was discovered that many units had been sold to consumers even though the products had failed internal quality testing.
	The firm was unaware that a lightning strike had interrupted power supply to the company's refrigeration units, causing products to be exposed to higher temperatures.
External Locus (Manipulated Factor)	When the company announced the product recall, it said that the defect was due to contamination that occurred at a Chinese contract manufacturer.
	The company didn't know that their overseas supplier had substituted a potentially harmful substance for the legitimate ingredient.
	The company recalled this product because it found out that a supplier had provided a counterfeit raw material.
	The company recalled several products after it was informed by its supplier that bacterial contamination might be present in a raw material.
	The product was recalled after the manufacturer found out that the distributor's refrigeration failed, causing bacteria to grow and the product to spoil.
	When the company recalled this product, it announced that the defect was due to a supplier error.
	In the product recall announcement, the company said that its supplier had falsified test results.
Purchase Dissatisfaction (Measurement Scale)	I feel dissatisfied with this purchase.
	I am unsatisfied with how this product performs.
	I am dissatisfied with my purchase of this product.
Repurchase Intent (Measurement Scale)	I will avoid purchasing this brand in the future.
	I would be less likely to buy this company's products in the future.
	I am less likely to purchase this brand in the future.
	When a product (such as spinach or granola bars) is recalled, I tend to not buy any brand of that product for a while.
	This product recall has decreased the chance that I would purchase this product in the future.

Note 1 11 valid responses; 2 discarded due to inappropriate response to screening item.

Table 3B.3 Q-Sort Set 2 Items

Constructs	Items
Unstable Cause – Corrective Action Provided (Manipulated Factor)	After conducting a product recall due to a counterfeit raw material provided by a supplier, the company has announced that it will conduct more frequent supplier audits and testing of raw materials.
	The company recalled a product because a supplier provided a contaminated ingredient. The company has stated that it has instituted new testing policies as a result of this issue.
	After the company recalled this product, it announced that it was conducting a comprehensive investigation into the cause of the defect.
Stable Cause – No Corrective Action (Manipulated Factor)	The company recalled a product, stating that the defect was due to a contaminated ingredient provided by a supplier.
	The firm indicated that the recall was due to contamination in its contract manufacturer's facility.
	The company recalled all of its frozen pizza products due to salmonella contamination. The cause of the contamination has not yet been determined.
	The company has recalled a product after testing revealed that it was contaminated with salmonella.

Note 1 8 valid responses; 6 discarded to inappropriate response to screening items

Table 3B.4 Q-Sort Set 3 Items

Construct	Sorted Items
Controllable (Manipulated Factor)	The company recalled the product because they detected salmonella in their finished goods.
	If a company tests a product and finds out that it is unsafe, they are responsible for making sure it is not distributed.
	The company recalled the product because they added the wrong amount of an ingredient during manufacturing.
	The company recalled a product after it was discovered that many units had been sold to consumers even though the products had failed internal quality testing.
	In the product recall announcement, the company said that its supplier had falsified test results.
Uncontrollable (Manipulated Factor)	The firm was unaware that a lightning strike had interrupted power supply to the company's refrigeration units, causing products to be exposed to higher temperatures.
	When the company recalled this product, it announced that the defect was due to a supplier error.
	The product was recalled after the manufacturer found out that the distributor's refrigeration failed, causing bacteria to grow and the product to spoil.
	The company didn't know that their overseas supplier had substituted a potentially harmful substance for the legitimate ingredient.
	The company recalled this product because it found out that a supplier had provided a counterfeit raw material.
	When the company announced the product recall, it said that the defect was due to contamination that occurred at a Chinese contract manufacturer.
	The company recalled several products after it was informed by its supplier that bacterial contamination might be present in a raw material.
Perceived Purchase Risk (Measurement Scale)	I feel like this product could be hazardous.
	I will lose money if this product doesn't perform as expected.
	I'm worried about the quality of the food supply.
	It's likely that I will be sick from food poisoning this year.
	I could get sick from consuming food that has quality issues.
	I feel like it is more likely than ever that the food I buy might have something wrong with it.
	I feel less safe about consuming eggs after hearing about the latest product recall.

Note 1 8 valid responses; 1 discarded due to inappropriate response to screening items.

Table 3B.5 Item Placement Ratios for Controllable, Uncontrollable and Purchase Risk

	Actual Construct Classification				
Theoretical Classification	**Controllable**	**Uncontrollable**	**Purchase Risk**	**Total**	**% Hits**
Controllable	**32**	16	2	40	80.00%
Uncontrollable	6	**38**	5	56	67.86%
Purchase Risk	0	4	**49**	56	87.50%
Total	38	58	56	152	78.29%
	84.21%	65.52%	87.50%		

Table 3B.6 Item Placement Ratios for Internal Locus, External Locus, Repurchase Intent and Purchase Dissatisfaction

	Actual Construct Classification					
Theoretical Classification	**Repurchase**	**Internal Locus**	**External Locus**	**Purchase Dissatisfaction**	**Total**	**% Hits**
Repurchase	**43**	1	0	1	55	78.18%
Internal Locus	0	**32**	10	0	44	72.73%
External Locus	0	10	**65**	0	77	84.42%
Purchase Dissatisfaction	12	1	2	**32**	33	96.97%
Total	55	44	77	33	209	82.30%
	78.18%	72.73%	84.42%	96.97%		

Table 3B.7 Item Placement Ratios for Stable and Unstable

	Actual Construct Classification			
Theoretical Classification	**Stable**	**Unstable**	**Total**	**% Hits**
Stable	**8**	11	24	33.33%
Unstable	16	**21**	32	65.63%
Total	24	32	56	51.79%
	33.33%	34.38%		

Table 3B.8 Final Measurement Items

Construct	Summary Measure	Label	Measurement Item
Purchase Risk (Pre-Test)	PRAgg	PR1	I'm concerned about food safety.
		PR2	I'm worried about the quality of the food I consume.
		PR3	I could get sick from eating food that has quality issues.
		PR4	I feel like consuming frozen cheese pizza could be hazardous.
Purchase Dissatisfaction	DissAgg	DIS1	I am unsatisfied with the quality of this product.
		DIS2	I feel dissatisfied with my purchase of this product.
		DIS3	This product did not meet my expectations for quality.
Repurchase Intent	RPurchaseAgg	RP1	This product recall has decreased the chance that I would buy a Chef Milo pizza in the future.
		RP2	I would be less likely to purchase the Chef Milo brand in the future.
		RP3	I would buy a different brand of pizza next time.
		RP4	I would avoid purchasing the Chef Milo brand in the future.
		RP5[1]	After this recall I would probably avoid buying frozen pizza of any kind for a while.
Recall Satisfaction	RecallSatAgg	RSat1	I feel satisfied with Chef Milo Corporation's statements about quality.
		RSat2	I'm satisfied with how the Chef Milo Corporation handled this product recall.
		RSat3	The Chef Milo Corporation seems to have handled this problem responsibly.
Supplier Responsibility	Not applicable[2]	SuppRes	I hold the supplier responsible for this problem.
Manufacturer Responsibility	Not applicable[2]	MfgRes	I hold the Chef Milo Corporation responsible for this problem.
Shared Responsibility	Not applicable[2]	SharResp	I feel that responsibility for this problem is shared by the Chef Milo Corporation and their supplier.

1. RP5 was dropped based on measurement model results. 2. Responsibility measures are single-items. All other items are the mean of items in the scale.

Table 3B.9 Manipulation Check Items

Construct	Label	Item	Scale
Locus	CheckLocus1	The defect that caused this recall happened at the supplier facility.	Disagree/Agree/ Don't Know
	CheckLocus2	The defect that caused this recall happened at the Chef Milo facility.	
	CheckLocus3	The salmonella contamination in the pizza came from Chef Milo's processing equipment.	
	CheckLocus4	The salmonella contamination in the pizza came from cheese supplied by Robert's Dairies, Inc.	
Controllability	CheckControl1	Chef Milo had control over the circumstances which caused this recall.	7 point "Very strongly disagree" to "Very strongly agree"
	CheckControl2	The supplier detected salmonella contamination in the cheese prior to selling it to Chef Milo.	Disagree/Agree/ Don't Know
	CheckControl3	The supplier had control over the circumstances that caused this recall.	7 point "Very strongly disagree" to "Very strongly agree"
	CheckControl4	Chef Milo detected salmonella contamination in the pizza before they distributed it.	Disagree/Agree/ Don't Know
Stability	CheckStability1	Chef Milo described what they are doing to prevent a similar problem in the future.	7 point "Very strongly disagree" to "Very strongly agree"
	CheckStability2	Chef Milo described what will be done to reduce the risk of the same defect happening again.	
	CheckStability3	I feel like Chef Milo has described what they are doing to correct this problem so that it doesn't happen again.	

Table 3B.10 Single-Item Covariates Measures

Covariate	Item	Scale
Age	Which category below includes your age?	7 point scale anchored by 20 or younger and 80 or older
Gender	What is your gender?	Male or Female
Education	What is your highest level of education?	7 point: Elementary/Middle School, High School, Some College, Bachelor's Degree, Some Graduate School, Master's Degree, Doctorate
Recall Awareness	I remember hearing about at least one food recall within the past year.	7 point "Very strongly disagree" to "Very strongly agree"
Illness Experience	I believe that within the past year I have become ill from something I've eaten.	7 point "Very strongly disagree" to "Very strongly agree"
Work Experience	Please indicate if you have any work experience in the following areas:	Check all that apply: Food manufacturing, Food service, and Healthcare