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TABLE OF CONTENTS

COST OF QUALITY: LESSONS FROM TOY RECALLS

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ABSTRACT

In spite of manufacturers' best efforts, products sometimes fail to meet customers' quality and/or safety expectations and have to be recalled. Recalling a product is a very expensive and complex task particularly in the context of international business. Recall data reported by the U.S. Consumer Product Safety Commission (CPSC) were analyzed for this study. The toys were classified into nine categories and the hazards posed by the toys were grouped in seven classes. Frequency of occurrence in each toy category and hazard class is presented. Monthly recalls have been analyzed and the countries of origin of the toys recalled have been reported. Lastly, the dominant hazards observed in each toy category have been identified.

Previous toy recall related studies mostly focused on the front end (retailers and consumers) of the value chain. While understanding the impact of toy recalls on retailers and consumers is very important, the role of the back end (manufacturers and suppliers) of the value chain must be understood to minimize recalls in the future. In the present study, we analyze recall data to first understand the nature of hazards posed by the toys, and then we propose a framework which includes regulatory agencies, retailers, and manufacturers so that an integrative approach can be taken in the context of international business to make toys safe. Next, we discuss the toy recall issue from the cost of quality perspective which includes prevention costs, appraisal costs, internal failure costs, and external failure costs. Lastly, we present quality management practices that can be applied at the back end of the value chain to enhance toy quality which is expected to reduce costly recalls.

INTRODUCTION

The automobile industry has been plagued with massive recalls in 2014. These recalls have renewed interest in understanding the root cause of recalls of various products and how they can be prevented. Similarly, the year 2007 was a tough one for the toy industry, one in which the U. S. Consumer Product Safety Commission (CPSC) reported a large number of toy recalls (Simms, 2007). The reason for these recalls included the presence of excessive amounts of lead, ingestion of dangerous substances, burns, cuts, and tip-overs that caused, or had the potential to cause, injuries. The popular press has suggested that cost-cutting pressure by U.S. importers/retailers forced Chinese manufacturers to cut corners which led to hazardous products (Blanchard, 2007; Brandt, 2008). The theory of quality management, however, suggests that cost reduction and conformance quality can be met simultaneously (McKone, Schroeder & Cua, 2001).

In this paper, first we review the recalls reported by the CPSC to understand the types of hazards posed by toys. Then we present an integrative framework that can foster coordination among regulatory bodies, retailers, and manufacturers. Lastly, we discuss some proactive quality

management practices that can help improve product safety and potentially minimize the trade-off between quality and cost.

TOY RECALL DATA SOURCE

The U.S. Consumer Product Safety Commission (CPSC) is an independent federal regulatory agency with more than 15,000 types of consumer products under its jurisdiction. The commission's primary objective is to protect the public from unreasonable risk of serious injury or death arising from unsafe consumer products. Data for this study were collected from CPSC website (http://www.cpsc.gov) reported from January of 2007 to March 2008. Our primary interest was only the year 2007, but there is a lag between the time a product is introduced in the market and the time it is recalled; hence, we collected data for three additional months. More than 33 million units were recalled during this period of time, and 258 injuries and 3 deaths were reported. Data gathered from the CPSC included the product name, the number of products included in the recall, the product category, the total number of units recalled, and the manufacturer, retailer, or importer conducting the recall. Also, we collected information on hazards posed by the toys, the month of the recall, any injuries or deaths reported, the retailers, and the country of origin of the toys.

These toys were divided into nine categories: action figures; dolls and accessories; educational; games; infant; children's jewelry; role play; vehicles, and other. The action figure category encompasses any figure-like toy traditionally used by boys. Dolls and accessories include figure-like toys and associated items used by girls. Educational toys are items not used purely for the enjoyment of children but involve a learning value of some kind. The game category encompasses board games and other games played with and by multiple children. Infant toys include raffles and baby teething rings. Children's jewelry was included as a category due to the vast number of recalls in this area. Role play toys are those that children use in dress up and pretend play. Vehicles included cars, trucks, boats and planes. The Other category included toys that did not fall in any one of the above categories; examples included spinning tops, tin pails, pool toys, wind-up toys, music boxes, and so on.

Hazards were limited to seven classes, which included potential injuries due to burns, cuts, fire, impact, ingestion, lead, and tip-over of a toy. Burns included instances of overheated toys causing burns. Cuts included any potential injury occurring due to sharp edges, or as a result of an appendage being pinched in a product. The Fire class included toys that overheated to the extent that they could start a fire. Impact items were moving/spinning parts of toys that could separate/break and impact the user. Ingestion was a broad class that included anything that children would put in their mouths with the potential of injury thereafter. While lead could be included in the former class, the decision was made to create a separate class due to the chemical nature of the hazard and the frequency of occurrence. Only one tip-over hazard was observed and was considered a class in itself for the purposes of this study.

TOY RECALL ANALYSES

In this section, we discuss frequency of recalls by number of products and/or by number of units. For example, if a product XYZ had 5 variations (such as color or size) and the number of recalled units across all variations was 1000, then we recorded that particular recall as involving 5 products (number of products) and 1000 units (number of units). Four categories of products,

Dolls and Accessories, Educational, Jewelry and Other, accounted for about 73% of all recalls by number of products (Table 1). By the number of units, two categories, Dolls and Accessories and Educational, account for about 68% of the recalls (Table 2). Lead and Ingestion comprise about 95% of the number of products recalled (Figure 1) and about 92% by number of units recalled (Figure 2). Interestingly, although a higher percentage of products was recalled due to lead content, more units were recalled due to ingestion than to lead content. The month of August (2007) had the most number of products recalled and the number of units recalled also spiked in this month (see Figures 3 and 4). Not surprisingly, the majority of the products recalled (about 96%) were made in China. India (about 3% by number of units) and Hong Kong (about 1% by number of products) were distant seconds (Figures 5 and 6).

Table 1
Number of products recalled by category

CATEGORY	SUM OF PRODUCTS	PERCENTAGE
Action Figures	29	6.43%
Dolls and Accessories	87	19.29%
Educational	83	18.40%
Games	14	3.10%
Infant	19	4.21%
Jewelry	67	14.86%
Other	93	20.62%
Role Play	14	3.10%
Vehicles	45	9.98%
Grand Total	451	100.00%

Table 2
Number of units recalled by category

CATEGORY	SUM OF UNITS	PERCENTAGE
Action Figures	2075800	6.17%
Dolls and Accessories	10479500	31.15%
Educational	12468760	37.06%
Games	520230	1.55%
Infant	326700	0.97%
Jewelry	2843470	8.45%
Other	1105100	3.28%
Role Play	742400	2.21%
Vehicles	3083500	9.16%
Grand Total	33645460	100.00%

Next, we highlight dominant hazard(s) by number of units in each toy category (Table 3). Lead was the dominant reason for recalls in the following categories: Jewelry (100%); Role Play (about 73%); and Vehicles (about 86%). Ingestion was the main reason for recalls in the following product categories: Action Figures (about 79%); Dolls and Accessories (about 90%); and Infant (100%).

Figure 1. Hazard frequency by number of products

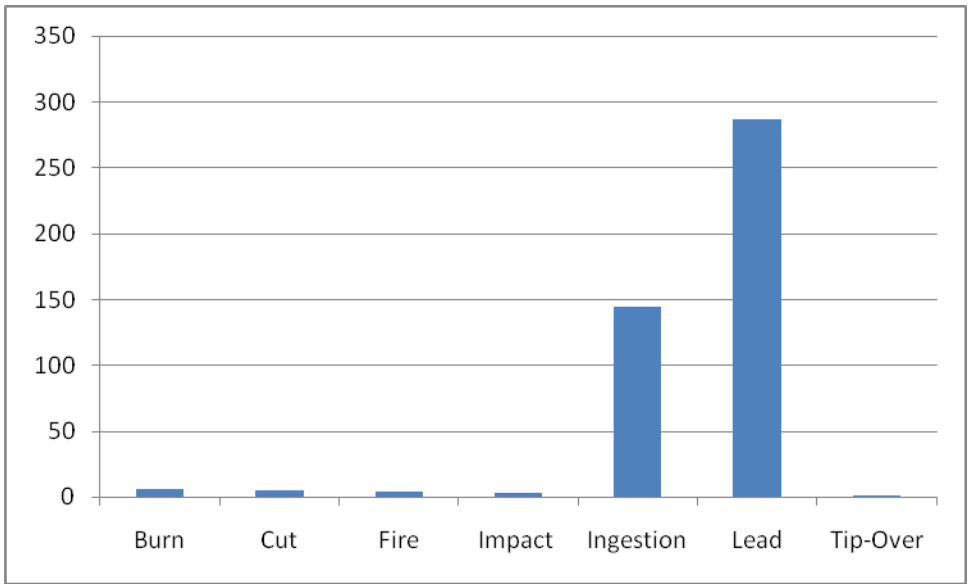


Figure 2. Hazard frequency by number of units

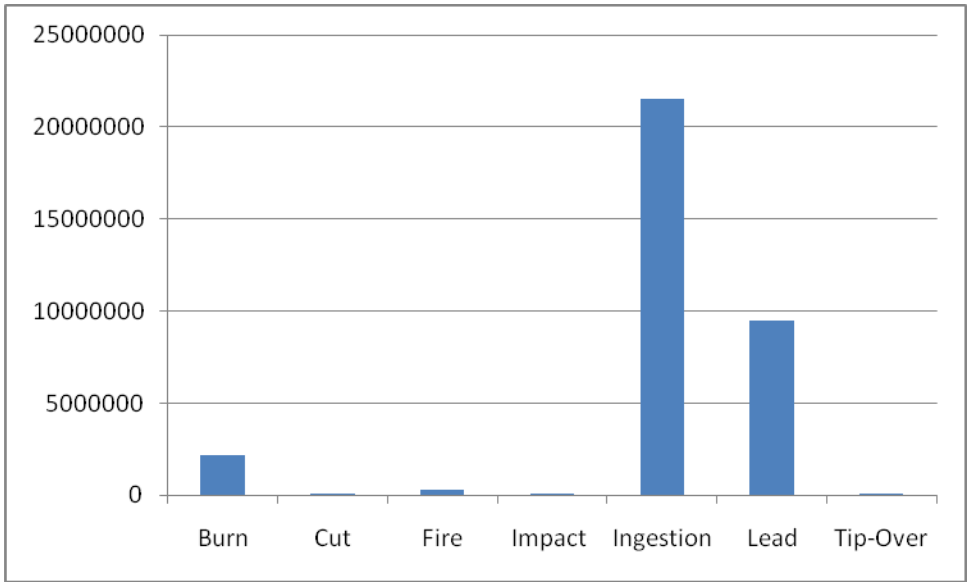


Figure 3. Number of products recalled by month

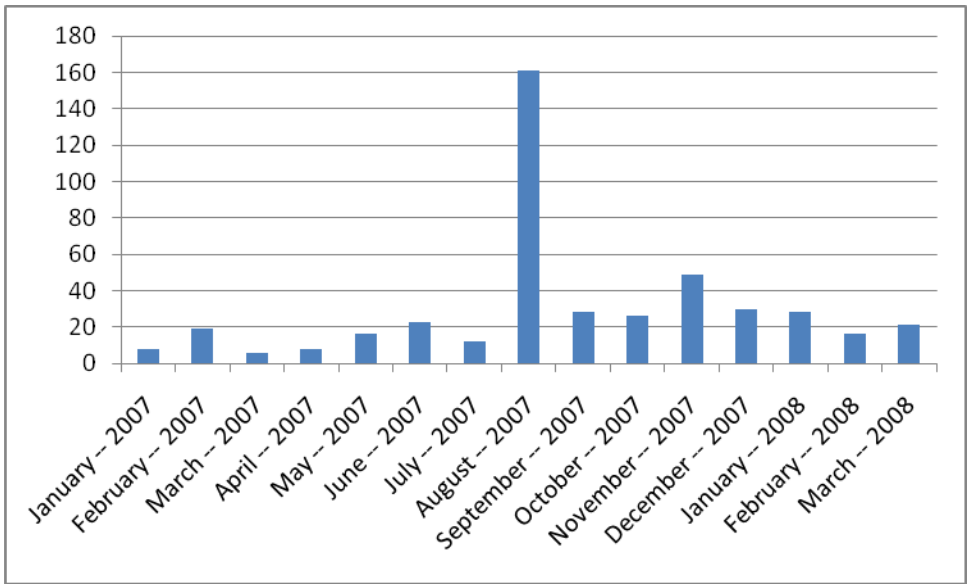


Figure 4. Number of units recalled by month

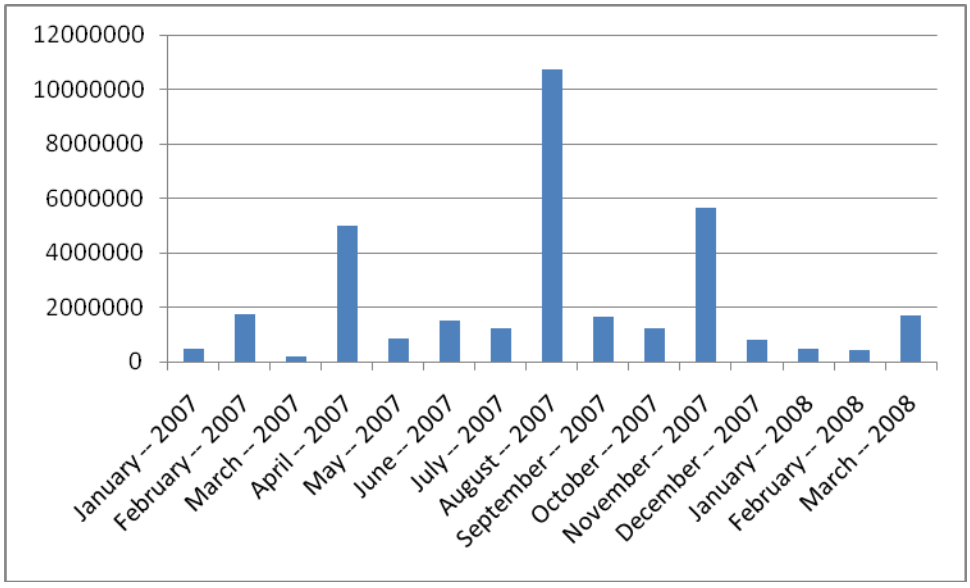


Figure 5. Recalls (number of products) by the country of origin

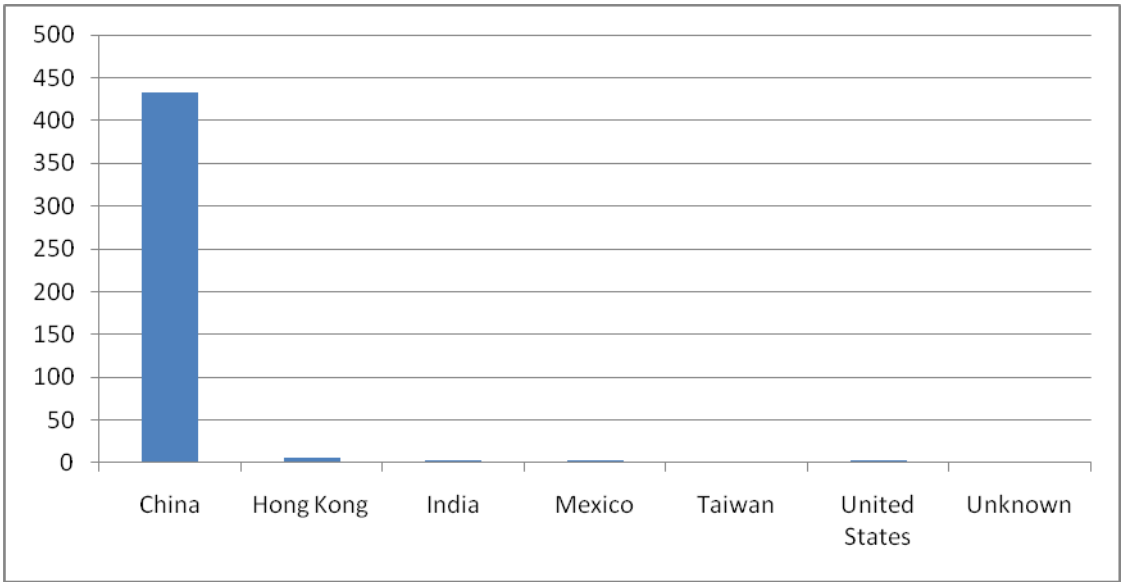
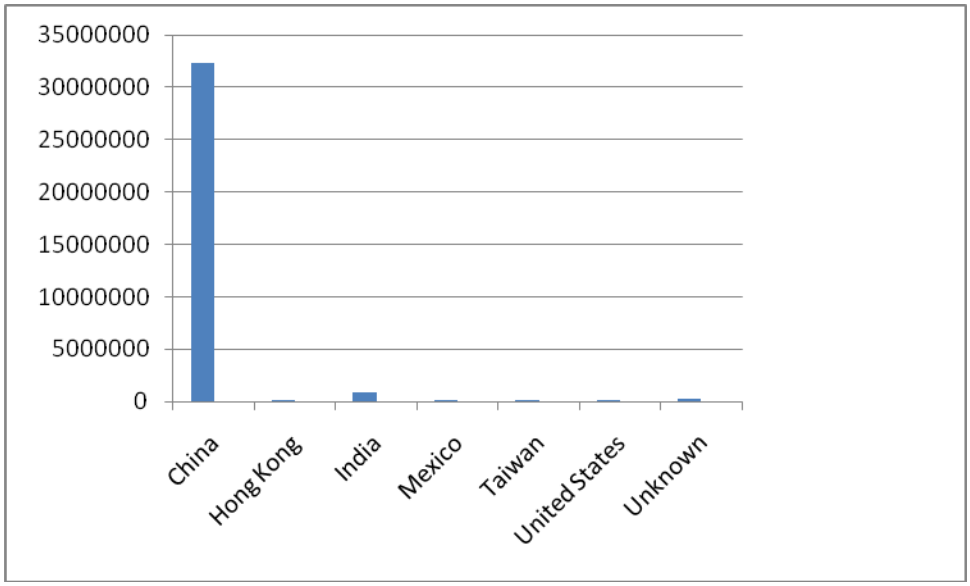


Figure 6. Recalls (number of units) by the country of origin



Some product recall categories had multiple major reasons, rather than one dominant reason, for recall. For example, the Educational product category had two major reasons for recalls: Ingestion (about 77%) and Burns (about 16%). Games were recalled for two major hazards: Ingestion (69%) and Lead (30%). Although lead was the dominant reason for recalling the products categorized under Role Play, a significant number of these toys were recalled due to ingestion hazards (about 24%).

Table 3
Dominant hazard in different categories

CATEGORY	HAZARD	NUMBER OF UNITS	PERCENTAGE
Action Figures	Ingestion	1645000	79.25%
	Lead	430800	20.75%
Action Figures Total		2075800	100.00%
Dolls and Accessories	Burn	113000	1.08%
	Cut	21000	0.20%
	Ingestion	9446500	90.14%
	Lead	899000	8.58%
Dolls and Accessories Total		10479500	100.00%
Educational	Burn	1985000	15.92%
	Cut	3100	0.02%
	Ingestion	9583900	76.86%
	Lead	896760	7.19%
Educational Total		12468760	100.00%
Games	Burn	1100	0.21%
	Impact	2600	0.50%
	Ingestion	360000	69.20%
	Lead	156530	30.09%
Games Total		520230	100.00%
Infant	Ingestion	326700	100.00%
Infant Total		326700	100.00%
Jewelry	Lead	2843470	100.00%
Jewelry Total		2843470	100.00%
Other	Cut	31000	2.81%
	Lead	1074100	97.19%
Other Total		1105100	100.00%
Role Play	Cut	6000	0.81%
	Ingestion	177000	23.84%
	Lead	542400	73.06%
	Tip-Over	17000	2.29%
Role Play Total		742400	100.00%
Vehicles	Burn	94000	3.05%
	Fire	332000	10.77%
	Lead	2657500	86.18%
Vehicles Total		3083500	100.00%

INTEGRATIVE FRAMEWORK

An integrated approach is needed to minimize hazards in toys. This approach requires coordinated efforts by regulatory agencies, retailers, and manufacturers. The following sections discuss the role of each of these entities.

CPSC and Chinese Regulatory Agency

The fact that most of the toys recalled were manufactured in China has led to open forums between China and the United States (Wilson, 2008). The CPSC hosted the U.S.-Sino Product Safety Summit in which an agreement was reached with the Chinese CPSC counterpart, the General Administration of Quality Supervision, Inspection, and Quarantine. In the agreement, the Chinese government agreed to increase inspections, assist the CPSC in tracking products with safety issues, exchange technical personnel with the CPSC, establish information exchanges with the CPSC regarding safety issues, and attend CPSC led training activities. The CPSC in turn translated nearly 300 safety standards into Chinese to help manufacturers understand U.S. product safety standards. These initiatives were put in place in response to the toy recall crisis. However, the agreement between the CPSC and its Chinese counterpart should be considered building blocks to strengthen their coordination, and need to be expanded to minimize hazards posed by toys.

The International Council of Toy Industries (ICTI) can also play an important role. China has been working with the ICTI and importers to develop a Code of Business Practices (CBP) and a seven-step ICTI Care Process. The former outlines the treatment of workers within the industry, while the latter establishes product standards for toy manufacturers. Under this arrangement, factories pay for an audit and receive a seal of compliance if they pass the inspection (Krueger, 2008; Servaes & Tamayo, 2013). Due to the globalized nature of manufacturing, these agreements need to be extended to CPSC counterparts in other countries. Memoranda of Understanding (MOU) with these countries can serve as a good starting point. The CPSC already has MOU with a number of countries. As recalls of Chinese made toys demonstrate, just having MOU is not enough; appropriate agreements and contracts should be made and, more importantly, their implementations need to be ensured.

Retailers

Toy recalls have prompted some retailers to rethink their roles. For example, Wal-Mart and Toys “R” Us Inc. have adapted a proactive approach by setting more stringent standards on lead even though prevailing laws did not require them to do so. Such a proactive strategy sends a signal to consumers that the company is prudent and diligent about the quality of the product they sell and bodes well for the corporate image (Ni, Flynn & Jacobs, 2014).Target has also indicated its renewed efforts to work with vendors, industry leaders, and the CPSC in combating the problems associated with unsafe toys. Wal-Mart, Toys“R” Us, and Target have primarily turned their attention to more stringent standards on metals and chemicals that have been shown to cause developmental problems in children, primarily lead (Pereira & Stecklow, 2008). The retail giants are requiring testing by independent laboratories and establishing requirements above and beyond the acceptable safe level of lead in products (Antonucci, 2008). Wal-Mart and

Toys “R” Us specified their goal to cut lead in toys from 600 parts per million to 90 parts per million (Szabo, 2008).

Toys “R” Us has also begun an initiative that would eliminate the use of PVC, or polyvinyl chloride, which is used to make products more flexible and has been used in baby rattles and teething rings. Retailers are also taking initiatives to achieve full traceability of toys from the component suppliers to the stores where they are sold (Pereira & Stecklow, 2008). For example, Toys “R” Us require suppliers to date code all products to further the traceability of goods (Sissell, 2008). These independent initiatives by retailers are steps in the right direction. However, isolated efforts by some retailers will do little to reduce hazards associated with toys unless these efforts are coordinated and expanded to include other retailers in the industry.

Manufacturers

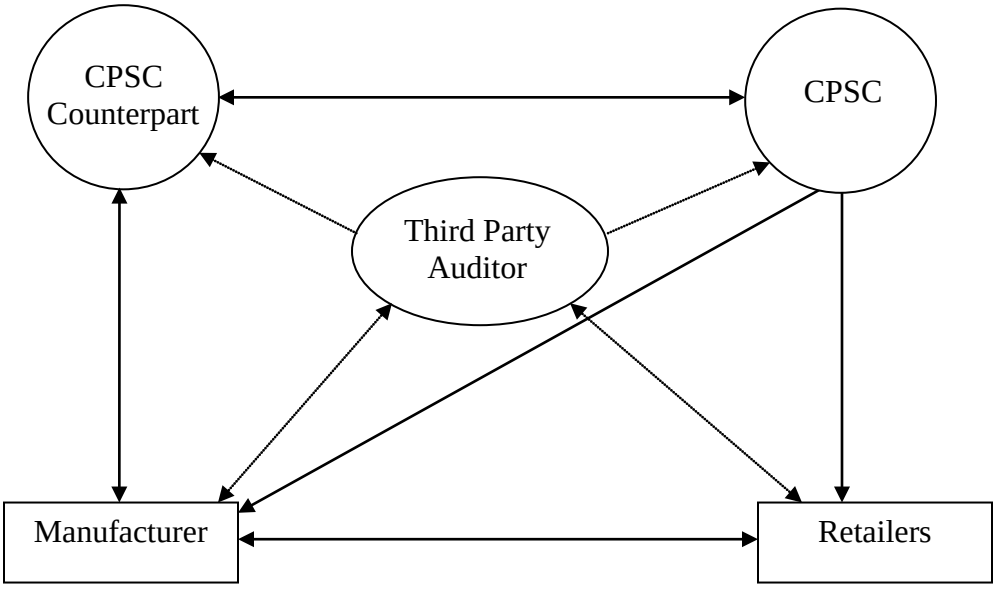
Manufacturers have been hit hard financially and lost consumer trust due to the toy recalls in 2007, so they are taking steps to prevent such occurrences in the future. For example, Mattel and Hasbro have implemented standards similar to those of the retailers and have stepped up oversight of manufacturing overseas. New oversight measures include the requirement that vendors use paint only from certified suppliers, use of independent on-site experts to monitor production, and test products post production (Desjardins, 2008). Fisher-Price has also responded by tightening its controls on the supply chain and testing, as well as reevaluating its own policies (Glynn, 2008). Testing, and especially unannounced testing, has been stepped up at its overseas operations.

In addition to the various uncertainties/risks associated with overseas manufacturing (Johnson, 2001; Gray, Roth & Leiblein, 2011), it also poses two major challenges throughout the supply chain: communication and accountability. The longer the supply chain, the harder it is to maintain communication between participants (Marucheck, Greis, Mena & Cai, 2011). Inadequate product specification and pressure to maintain shorter lead times make matters worse (Brandt, 2008). Accountability fades as activities are outsourced to other smaller companies which in turn outsource to other even smaller companies (Teagarden & Hinrichs, 2009). Eventually, manufacturing activities are at least two or three stages removed from the Chinese company to which the production was outsourced. For example, Mattel contracted with a manufacturer in China which sub-contracted to another manufacturer, which in turn sub-contracted yet again. This third sub-contractor did not use the approved paint, triggering a massive toy recall due to high levels of lead (Simms, 2007). With so many stages between the retailer and the sub-contractor at the furthest end, the root cause of problems becomes almost impossible to trace, should there be a recall. Use of RFID tags and requiring that the Bill of Materials contain the origin of each part used in production can help improve traceability (Thilmany, 2007). The use of RFIDs for inventory management is growing but their use for tracing and tracking recalled product is still in its infancy (Marucheck, Greis, Mena & Cai, 2011).

Figure 7 represents an integrated approach to information exchanges among regulatory agencies, retailers, and manufacturers. At the broader level the CPSC and its counterpart in China (or other relevant countries) need to have common goals and objectives. The standards agreed upon by both the CPSC and its counterpart(s) have to be communicated to the retailers so they can enforce these standards. Monitoring manufacturers’ activities upstream has been a major problem particularly when manufacturing tasks have been outsourced and subsequently

sub-contracted to a number of vendors. For example, Mattel allowed a manufacturer, with whom it had a trusted 15 year relationship, to perform its own quality control tests, but that relationship could not prevent products from being contaminated with lead (Spencer & Casey, 2007). This emphasizes the need to mandate independent third-party quality testing/auditing. These independent auditors will report any exceptions/violations to regulatory agencies, manufacturers, and retailers so that stakeholders are kept informed and prompt corrective action can be taken.

Figure 7. Coordination across the supply chain



COST AND QUALITY

The quality management literature classifies costs of quality into four major categories as follows: (1) Prevention costs – costs incurred to keep nonconforming products from occurring (e.g., product quality awareness training, product redesign, etc.); (2) Appraisal costs – costs associated with checking if products meet specification (e.g., inspection/testing, calibration of measuring instruments); (3) Internal failure costs – costs incurred as a result of unsatisfactory quality found before a product reaches customers (e.g., scrap, rework, etc.); (4) External failure costs – costs incurred when poor quality products reach customers (e.g., recall, product liability, etc.). From a quality management perspective, investment in prevention and appraisal costs is expected to minimize expensive internal and, particularly, external failure costs. Toy retailers have blamed toy manufacturers for poor quality while suppliers have blamed manufacturers for price pressure. This presents a classic scenario of trade-off between cost and quality.

From a quality management perspective, we argue that it need not be an either/or proposition. In fact, the theory of quality management suggests that conformance quality and low cost can be achieved simultaneously if top management can bring about changes in an organization that motivate employees to do their best work in an environment where they can report mistakes without fear (Anderson, Rungtusanatham & Schroeder, 1994; McKone, Schroeder & Cua, 2001). A product is said to have conformance quality if it meets design

specifications agreed upon by the retailer/importer and the manufacturer. Attaining higher degree of conformance quality will decrease rework and scrap costs leading to cost savings. Furthermore, the toy recalls observed fall into the worst of the four cost of quality categories, the external failure cost. Recalls also lead to latent costs that are much more difficult to value, such as loss of customer satisfaction and goodwill toward the company. Expenses arising from these recalls generally exceed the costs of manufacturing, not to mention the legal issues and fines incurred in the event of penalties levied due to injuries or deaths. With the cap for penalties likely rising, these costs will increase and potentially threaten the existence of smaller importers, and take a large portion of the bottom line of the larger retailers and manufacturers (Krzykowski, 2009). Therefore, it would be to manufacturers' and retailers' advantage to proactively apply quality management practices as suggested below.

Quality at the Source

Quality at the source empowers employees to become their own inspectors and to take responsibility for the quality of their output. However, this empowerment would do little unless the employees are trained in how to identify and solve problems using statistical process control tools in a team environment where management fosters quality culture. Companies need to do a better job of coordinating and monitoring the behavior of suppliers with respect to product safety. In a study of noncompliant behavior among Chinese apparel and textile suppliers, Jiang (2009) observed more sustainable compliance when buyers used cooperation and collaboration with the suppliers as opposed to threat and coercion. Thus, the notion of quality at the source need not be confined within an organization but, rather, should be extended across suppliers and manufacturers along the supply chain.

Quality Function Deployment

Hora, Bapuji & Roth (2011) empirically show that the time to recall, as measured by difference between product recall announcement date and product first sold date, is longer for products with design flaws than for products with manufacturing defects. Longer delay in recalling a defective product has greater potential for safety hazards and costs. Thus, the importance of product design on product failure and consequent recall cannot be overemphasized.

While lead has been a highly publicized reason for recalling toys, manufacturers have also encountered more dangerous product defects involving ingestion hazards. For example, Mega Brands had to completely redesign its Polly Pocket and Batman toys due to magnets that would fall out of the toys and be ingested by children. The company changed the design by embedding the magnets within the plastic and then sealing them with a cap to avoid their escape. However, these changes were made after the fact and, hence, are reactive. A proactive approach is needed. Quality Function Deployment (QFD) is a process that integrates customer voice, design, and manufacturing so that products meet the expressed needs of customers. Customers and engineers speak different languages. QFD translates customer requirements into engineering specifications. For example, ingestion was one of the main reasons for infant product recalls. To prevent ingestion of small parts (a customer requirement), product design teams can use QFD (House of Quality in particular) to develop specifications on the minimum part size allowable and/or appropriate harness which ensures that small parts will not become loose during use.

Good Manufacturing Practices and ISO Certification

Manufacturing facilities in FDA-regulated industries (e.g., drugs, food, and medical devices) are subject to inspection by governmental organizations. Inspectors assess a manufacturing facility's compliance with "Good Manufacturing Practices (GMPs)." Inspectors check whether the production and control procedures are designed to have all reasonable precautions to meet or exceed acceptable quality and safety levels of the finished products. In addition to checking the existing manufacturing practices in details, these inspections usually involve spot checks of records and conversations with random employees during plant tours. Toy industry can greatly benefit from lessons learned by companies in the FDA-regulated industries.

Based on a sample of 30 pairs of regulated drug manufacturing plants in the U.S. mainland and Puerto Rico, Gray, Roth & Leiblein (2011) found that Puerto Rican plants operated with a significantly higher quality risk than matching plants operated by the same firm located in the mainland U.S., on average. The authors argue that the difference in quality risk is primarily driven by cultural distance (Hofstede, 2001), which acts as a barrier to consistently transfer the company's knowledge of good manufacturing practices (GMPs) across offshore plants. Therefore, cultural distance should be paid close attention to when applying the tenet of GMPs in toy manufacturing facilities across different geographical locations.

ISO certification can play an important role in ensuring consistency of procedures followed by suppliers and manufacturers. ISO certification requires detailed documentation of procedures be kept and the steps stipulated in these documents be adhered to. For example, the best procedure used to ascertain lead content in a toy part can be documented and shared across suppliers and manufacturers. ISO certification will ensure that these documents are kept and the steps included in these documents are followed consistently across the value chain. An accredited certifying agency, a third party team of auditors, visits the site to check consistency between steps stipulated in the quality manual and actual practices observed in the manufacturing plant before recommending the site for certification.

Failure Mode and Effects Analysis

Supply chains have become more complex due to outsourced manufacturing activities even in highly regulated industries such as food, pharmaceuticals, medical devices, consumer products and automotive. Increasingly, research and design activities are also being outsourced (Marucheck, Greis, Mena & Cai, 2011). Thus, the practice of identifying potential failure modes of a product at the design phase has become crucial to minimize recalls.

The objective of Failure Mode and Effects Analysis (FMEA) is to identify all the ways a product can fail (or become unsafe) using a Fault Tree Diagram. The purpose of this analysis is to identify the failure modes, understand the causes of failure, estimate the impact of failure (e.g., safety, cost, others), and suggest corrective actions. Thus, FMEA can be used to explore potential hazards posed by a product so remedial measures can be taken before the product hits the market. Manufacturers need to consider potential errors as seriously as the ones they have already made and learn from both. A work environment where employees are encouraged to explore and report potential design flaws or other quality problems without fear is essential to creating a proactive learning culture which involves studying, listening, testing, and tracking (Bapuji & Beamish, 2008).

CONCLUSION

About 60 percent of the world's toys are produced in China (Brandt, 2008) and about 80% of the toys that come into the United States are made in China (Spencer & Casey, 2007). Although lead contamination and loose small magnets were the main reasons for toy recalls, analyses showed that other hazards were also present. Several factors have contributed to these recalls. At the broad level there needs to be a close coordination between CPSC and its counterpart(s). More importantly, CPSC counterparts have to do a better job of enforcing the standards and continually sharing relevant information with the CPSC. Third party auditors can play an important role by monitoring compliance at the manufacturers' and/or sub-contractors' sites and relaying that information to the stakeholders. While third party testing is somewhat reactive in nature (i.e., after the fact), it is still better than discovering quality problems once the products have already reached the market. A more proactive approach should be taken by retailers and manufacturers; they should work together with their sub-contractors and vendors to improve conformance quality by applying quality management practices discussed earlier. In addition, companies can learn not only from their own recall experiences but also from other recalls in the industry (vicarious learning). Such knowledge improves product designs, production processes, and risk management strategies (Thirumalai & Sinha, 2011).

Historically, retailers put pressure on manufacturers to reduce costs and pretended that this would not have any consequences. The 2007 recalls have shown that this cost cutting pressure is transmitted from the main manufacturer to the n^{th} sub-contractor where compliance is not enforced and transparency is lacking. However, when a recall happens, all entities in the supply chain, from retailer to small vendors, suffer and incur losses which are often more than the cost they wanted to cut in the first place. Therefore, much can be gained if retailers and manufacturers work under a common goal.

According to an analysis reported by CNN, 2014 is shaping up to be a year with one of the largest number of passenger cars and trucks recalls in the U.S. history (Isidore & Wallace, 2014). Roughly one out of every ten of passenger cars and trucks on the road has already been recalled. These events have renewed the interest in understanding the root cause of recalls of various products and how they can be prevented. Our study intends to shed light on toy recalls to understand causes of recalls and offers suggestions to minimize these recalls in the future.

Products can be made in China for 30 cents when they would cost $1 to manufacture in the United States (Winston, 2007). This fact has been an obvious driver for United States' toy retailers to purchase toys from China and this trend is expected to continue. So the toy industry needs to make accountability a priority in its extended supply chain to attain both low cost and high quality, not low cost at the expense of quality. Each year, the $22 billion U.S. toy industry sells about 3 billion toys through a wide range of retailers (Schmidt, 2008), so manufacturers that manage their intricate supply chains better stand to profit from this vast yet very competitive market.

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