

# UNRAVELING THE FOOD SUPPLY CHAIN: STRATEGIC INSIGHTS FROM CHINA AND THE 2007 RECALLS\*

ALEDA V. ROTH  
Clemson University

ANDY A. TSAY  
Santa Clara University

MADELEINE E. PULLMAN  
Portland State University

JOHN V. GRAY  
The Ohio State University

The March 2007 pet food recall and a rapid progression of comparable incidents have exposed the real potential for food supply chain contamination and disruptions. When organizations source via multilayered supply chains with poor visibility they are particularly vulnerable. In this paper, we develop a conceptual framework called the “Six Ts” of supply chain quality management — traceability, transparency, testability, time, trust and training — which are relevant for any product but are especially critical to the preservation of public welfare through a safe food supply. We describe the globalization of food supply chains and present data on the trends of U.S. food import volumes, both in aggregate and specifically from China. We also highlight the inherent difficulties and risks posed by global food supply chains, using those originating in China as an example. Finally, we provide a research agenda and questions to be addressed regarding the application of the six Ts in global food supply chain management.

*Keywords:* global supply chain; supply management; food safety; emerging markets; quality risk; sourcing from China

## INTRODUCTION

After a 5-month investigation, on March 15, 2007, the U.S. Food & Drug Administration (FDA) announced that “contaminants (were found) in vegetable proteins imported into the United States from China and were used as ingredients in pet food” (USFDA 2007). Over the subsequent months, hundreds of pet food brands were recalled. These events were followed by an avalanche of reports in the popular press about problems with other

Chinese-made products (Byron 2007; Story 2007; Welch, Woellert and Carey 2007). In fact, of the 152 consumer products recalled by the United States Product Safety Commission since January 2007, 104 were made in China. Chinese manufacturers have been associated with twice as many recalls in the United States in 2007 as organizations of any other country, including the U.S. (Farah 2007). Of the product categories experiencing significant recalls, food may hit closest to home for the greatest number of consumers. FDA reports of carcinogens, pesticides, bacteria, drugs and heavy metals in imported foods have served as a wake-up call to the American populace about the quality risks of global sourcing, especially from China.

These recent incidents have raised public awareness of the ubiquity of Chinese products in the global food supply and have caused concern about the business and

---

\*Like all invited papers and invited notes, the original version of this manuscript underwent a double-blind review process.

Acknowledgment: We thank Xiaojing Dong, Ling Li, Yuexin Wang, Hua-Hung (Robin) Weng, Runmei Wu and Xiaona Zheng for sharing with us their insights on this complex problem, and Lisa Bosman, Jeff Shockley and Katie Williams for their research assistance. We appreciate the efforts of the Co-Editor and two anonymous reviewers, who greatly improved the quality of our exposition.

supply management practices that have allowed tainted food to get so close to end customers. Consumer advocate groups and, more recently, food makers themselves are increasingly demanding regulations for food safety (Zhang 2007). Suppliers, manufacturers, distributors, wholesalers and retailers are piling on inspections. We believe these tactics alone will be neither sustainable nor effective in the long run. Instead, we turn to the familiar and fundamental principle of designing quality into processes, which requires a deep understanding of the root causes for process failures (Giffi, Roth and Seal 1990).

In this paper, we offer a framework for supply chain quality management that will provide a strategic focus to the tremendous energies that are now being brought to bear on this major problem. While our framework is applicable to any supply chain, it crisply acknowledges that best practices for managing global end-to-end supply processes for “hard” products have subtle but important differences from those for perishable consumables like food. Our framework proposes the “six Ts” of supply chain quality management: (1) traceability, (2) transparency, (3) testability, (4) time, (5) trust and (6) training. Traceability is the ability to track a product’s flow or attributes throughout the production process and supply chain (Golan, Krissoff, Kuchler, Calvin, Nelson and Price 2004). Transparency is the lack of secrecy, or the systematic provision of product and processing information under informal and formal agreements (CDA 1992). Testability refers to the ability to detect an attribute of a product. Time refers to the duration of specific processes. Trust is the expectation that parties will make a good-faith effort to behave in accordance with any commitments, be honest in negotiations and not take advantage of the other even when an opportunity to do so is available (Hosmer 1995). Training is the systematic process of developing knowledge, skills and attitudes regarding international standards of quality, food safety and best practices. These six Ts are critical factors associated with product (food) quality (see Figure 1).

Our six Ts blueprint for quality improvement can be interpreted in terms of the familiar *Define–Measure–Analyze–Improve–Control* (DMAIC) approach of Six Sigma. For an organization trying to improve the quality of the products it sources and delivers through a global supply chain, the six Ts serve as both necessary inputs and desired outputs in each DMAIC phase. In the Define phase, the project team must be formed, the project deliverables defined and the team trained. Traceability, or being able to “map” the supply chain, is an input to this phase and training is an outcome of this phase. By training we mean ensuring both that the supply chain managers are trained on the practices required to ensure high-quality product and that the global suppliers are trained on those same expectations and standards.

In the Measure phase, the team identifies the key metrics relating to quality, implements plans to collect them,

and obtains a baseline. In this phase, testability must be an outcome, as tests must be implemented to allow measurement at each necessary point in the supply chain.

In the Analyze phase, the team gathers data and attempts to determine the root causes of any gaps in performance. Transparency of procedures and norms is necessary to begin this process. By means of the root cause analysis, buyer–supplier trust can be improved throughout the supply chain.

The Improve phase may involve improvement in many metrics, including in the areas of traceability of inputs, testability of products and transparency of processes across the supply chain. One specific area of focus in the Improve phase should be “time.” For food products, a reduction in time in the supply chain will reduce the risk of many types of quality failures, such as those related to perishability.

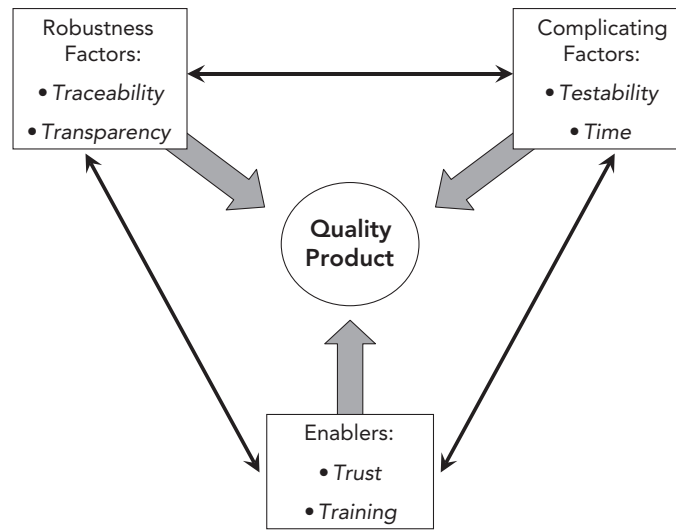
Finally, in the Control phase, any improvements made in time, testability, transparency and/or traceability can be shared system-wide through training. In this phase, continuous process improvement and discussion help to increase the trust level throughout the global supply chain. In the sections below, we examine a number of factors that have an impact on the application of the six Ts framework to global food supply chain issues.

The remainder of the paper is organized as follows. We begin by outlining the evolution of the supply chains that provide food to American consumers, and we subsequently detail China’s increasing role in the global food industry. We then present recent FDA data regarding inspection of Chinese food exports and identify special complications for the six Ts that arise from Chinese food suppliers’ cultural norms and business conditions. Following this, we develop a research agenda for food supply chain quality management that is organized around the six Ts. Finally, we conclude with a summary and discussion of the implications of the six Ts for the global food supply.

## **TRENDS IN MODERN FOOD SUPPLY CHAINS**

The structure of today’s typical food supply chain is shown in Figure 2. A farmer/grower starts with farm supplies — machinery, seeds, agro-chemicals and/or other inputs — and then sells either directly to a food processor or indirectly through storage and marketing via a cooperative group or consolidator. Growers do have the potential to reach down the chain to distributors, retailers and even consumers (e.g., farmers’ markets and restaurants). Other players in the chain can also extend their reach. Large manufacturers typically have a direct channel to retailers. The exact supply chain path for a particular food product depends on the product characteristics, size and market power of the supply chain members (Maloni and Brown 2006). Traceability and transparency in food supply chains, however, are especially affected by three major forces: (1) globalization, (2) consolidation and (3) commoditization.

**FIGURE 1**  
**Six Ts of Supply Chain Quality Management**

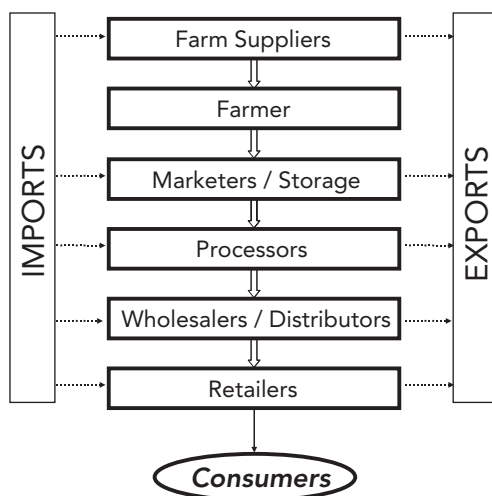


### Globalization

Before the last several decades, the traditional U.S. food supply chain was predominantly regionally localized and consisted of mostly small-to-medium size independent and local businesses. These stores were supplied by regional producers and manufacturers of agricultural products. The farms that fed into these supply chains were a mix of medium-scale family farms with some specialization. The logistics system was relatively inefficient and fragmented, with primarily regional and local reach (Saltmarsh and Wakeland 2004).

Pressures for cost reduction throughout the food supply chain, driven in part by the increasing competition in the retail grocery arena (Hayward and Nolan 1990), have contributed to the rise of what is now considered the mainstream food supply chain model. The model moved beyond regional to include global participation for importing (to reduce costs) and exporting (to generate revenues) in all levels of the chain. The typical buying organizations are large, vertically integrated multinationals with huge product diversity and a focus on low cost and efficiency. More than 80 percent of food sales are delivered via this model, and participating organizations consist of large publicly traded or privately held businesses with both national and global reach (Saltmarsh and Wakeman 2004).

**FIGURE 2**  
**Generic Model of Food Supply Chain  
 (One Ingredient)**



### Consolidation

With only small margins attainable in most links of the food supply chain, pressures to reduce cost and maximize profits have led to consolidation across many food categories and all levels of the food supply chain. The field is now dominated by a few large businesses, such as Wal-Mart, Carrefour, ConAgra, Archer Daniels Midland (ADM), Cargill and Unilever. The scale of some of these organizations is exemplified by Nestle, which employs over 253,000 people in more than 500 factories worldwide (Hamprecht, Corsten, Noll and Meier 2005). The large producers of basic foodstuffs (e.g., Cargill and ADM), which control much of the production and processing of grain and corn products, continue to expand downstream in the supply chain, while leading grocery retailers integrate vertically up the chain and horizontally across markets. The consolidation and resulting economies

of scale have concentrated control of the markets in the hands of a few and have erected barriers against the entry of potential competitors.

### **Commoditization**

Food products are either value added or commodities. Value-added foods are those for which the specific nature of the food is of central importance to customers. Vegetables, certain meats and seafood typically fall into this category, as do “credence attribute” foods. Credence attributes are content or process attributes that are difficult for the consumer to detect during or after food consumption (e.g., calcium-added, country-of-origin, organic or preferred processing techniques). For these types of products, value has traditionally been derived from close relationships with the supply chain members and the presence of trust, transparency and traceability (e.g., assurances of expected quality through close identification of producer, branding or certification). In most cases, these food items enjoy higher margins throughout the supply chain because consumers are willing to pay more to ensure certain quality, growing or production practices (Saltmarsh and Wake-man 2004).

In contrast, commodity foods are traded as undifferentiated goods, generally in large quantities. Food is aggregated from multiple global sources, standardized and traded on spot markets based largely on price alone. Transactions often take place over long distances; and standardization reduces the need for communication and knowledge about the specific product characteristics. This facilitates trade, but at the expense of traceability. Here, the main criteria for supply managers are high levels of standardization, high volumes and low prices.

Consolidation has led to commoditization of the food industry, including some of the traditional, value-added foodstuffs. This is due in part to the influence of the large-scale food processors and retailers that have stepped into this area in pursuit of the consumers who are willing to pay high premiums for products certified as organic, nongenetically modified organisms (GMO), fair trade, etc. (Howard 2007). Take, for example, Dean Foods, the largest U.S. commercial milk bottler. Since acquiring the Horizon organic milk business, Dean now controls 55 percent of U.S. organic milk production, and the transparency of the values-oriented practices has degraded (Kastel 2006). This shift from the value added to the commodity model can also be seen in Wal-Mart’s strategy to grow organics in China (Gogoi 2007). Owing to these trends, the more localized food supply chains, which are generally more diverse and involve a far larger number of independent businesses, have been reduced to a niche, and their infrastructure has been eroding at high rates (Jarosz 2000).

### **Global Sourcing of Ingredients**

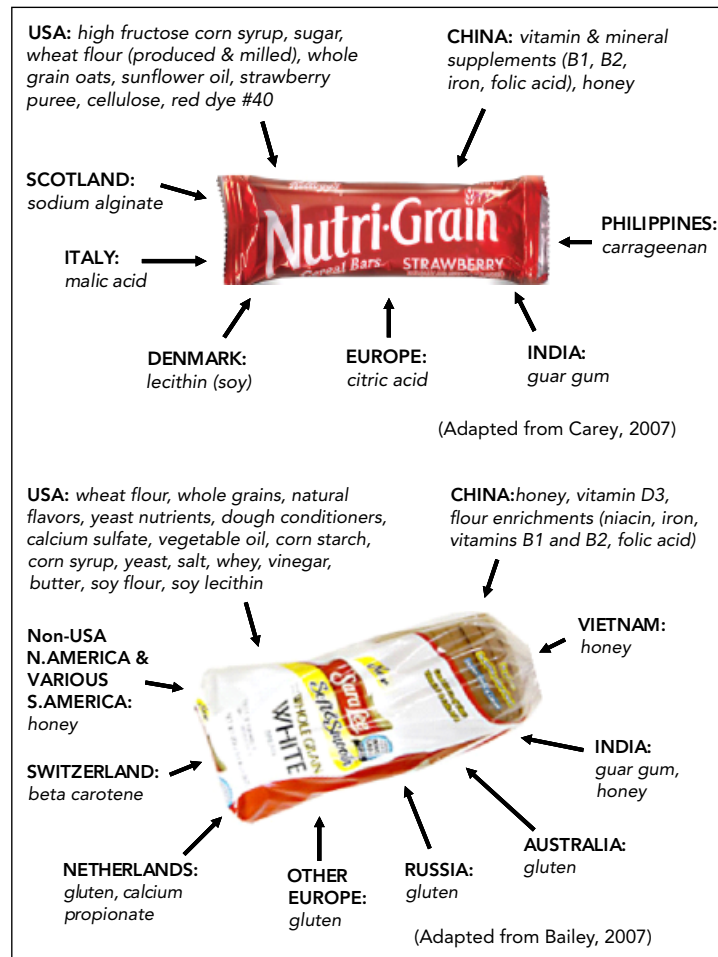
Given the three forces — globalization, consolidation and commoditization — two of perhaps the most revealing findings for consumers arising from the food recalls are the depth of global sourcing of food ingredients and the magnitude of the outsourcing of production of branded products to contract manufacturers. The general global sourcing model advocates that original equipment manufacturers (including food brand owners) offload “tangible assets” and functions deemed peripheral, in order to focus on strategic value-adding core competencies (Prahalad and Hamel 1990). As their reward for increasing what they procure from outside parties, these organizations are promised lower costs, financial and operational flexibility, and improved return on assets. Organizations in all industries are increasingly able to source from distant locations due to progress in information technology, efficient and far-reaching logistics networks, the liberalization of economies around the world, and the removal of trade barriers.

Extensive global sourcing of ingredients is certainly today’s reality for food products. In Figure 3, we show this to be true for two everyday items with familiar brand names. As is the case for any product, global sourcing of food and ingredients complicates supply chain management, with an increased number of entities involved in the supply network, a greater number of product hand-offs, and multiple distance factors (e.g., geographic, administrative, cultural and economic factors (Ghemawat 2001)). The resulting supply chains are typically accompanied by (1) additional costs for oversight, logistics, pipeline inventory and quality management; (2) heightened vulnerability and greater supply risks stemming from potential supply disruptions, lack of accountability, lower visibility and quality failures; (3) issues concerning global financing and funds transfer; and (4) lower responsiveness due to longer lead times.

Given these hazards — and perhaps to avoid being criticized for not supporting domestic farms, workers and suppliers — many food organizations are secretive about their international sourcing activities and are deliberately vague about ingredient sourcing. The primary reasons for global sourcing, according to companies we queried in a pilot study, are lower costs and insufficient local supplies (see Appendix).

Thus far, consumers have been relatively trusting of retailers, food makers and distributors. Before March 2007, few American consumers thought to ask about the country-of-origin for ingredients in their food. This is in part a consequence of branding efforts by the organizations: one goal of product branding is to increase customers’ confidence that the brand owner will navigate the marketplace in their best interest. Consider Whole Foods, whose branding includes a declaration that it will not sell anything containing any of the 83

**FIGURE 3**  
**Global Sourcing of Food Ingredients: Two Examples**



ingredients it deems “unacceptable in food products” (Whole Foods 2007). Even Whole Foods, which favors local producers, does not restrict its suppliers from sourcing their ingredients globally.

### FOOD SOURCING FROM CHINA

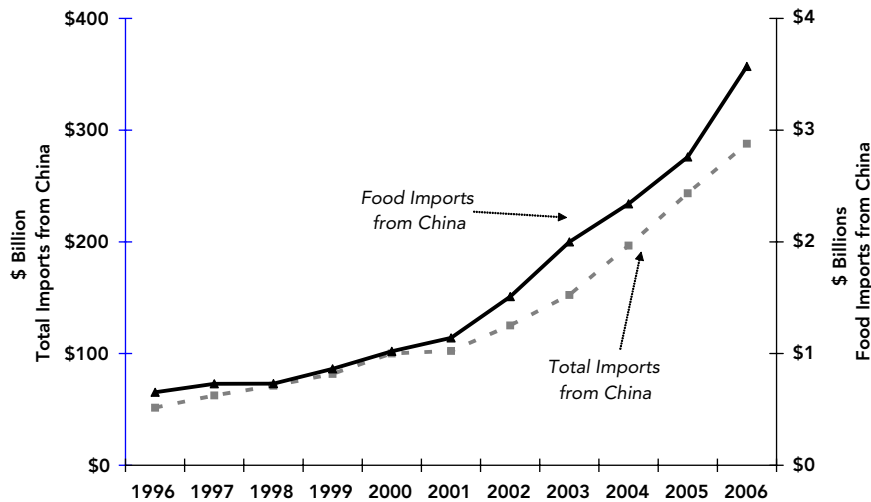
With its low labor costs and growing set of food production capabilities (and, as critics emphasize, lax enforcement of environmental and labor laws), China has rapidly become a dominant supplier to much of the world. In this section, we present the general trends in American importing of food from China. We then scrutinize the realities of the FDA’s ability to police these product flows. Finally, we discuss behavioral factors and business conditions in China that provide essential context for the recent spate of quality problems.

#### Sourcing of Foods from China is on the Rise

Food importing in the United States is big business and getting bigger. According to the U.S. Census, the imported proportion of U.S. food consumption has

grown from 7.9 percent to 9.6 percent between 1997 and 2005, roughly a 22 percent gain; and the dollar value of this segment has increased 59 percent, from \$32.3 billion to \$51.4 billion. The FDA’s Office of International Programs reports that 80 percent of seafood and 20 percent of produce is imported from abroad. U.S. food import volumes from China are skyrocketing when compared with overall food import volumes (U.S. Census Bureau 2007a,b). Notably, Figure 4 depicts that the growth rate for food imported from China has closely paralleled that of total imports from China over the past decade. All the while, food imports have remained “under the radar” to most except for industry insiders. The popular press attention regarding sourcing from China has instead focused on electronics, textiles and toys — products whose quality failures have a less serious impact on the typical U.S. consumer than do off-quality food and food ingredients. Contaminated food ingredients in miniscule amounts may not be readily detected, and consequently their cumulative impact on public health and well-being may not be known for years.

**FIGURE 4**  
Trends in U.S. Imports from China: Food and Total.



Sources: <http://www.census.gov/foreign-trade/balance/c5700.html#2007> (for total imports) and <http://censtats.census.gov/sitc/sitc.shtml> (for food imports)

### Realities of FDA Inspections

As consumers and food companies seek to ensure the safety of globally sourced food, many are calling for more government support. Yet the food safety infrastructure is highly fragmented in the United States — 12 federal agencies administer 35 different food safety laws. There is a heavy reliance on state and local governments to police food retailers. Our examination of FDA records indicates that this agency inspected 52 Chinese plants between January 1998 and September 2005.<sup>1</sup> Of these, only five inspections were classified as “official action” (OAI), the most serious classification, and 28 plants received “no action” (NAI) from the district (indicating no significant violations of regulations). The remaining 17 plants received “voluntary action” (VAI), indicating the need to resolve some relatively minor violations. Two plants did not have a usable classification. Gray, Roth and Tomlin (2007b) provide detailed information regarding the FDA inspection process, the precise meaning of the codes, and the general approach to the collection of FDA data. A comparison of these 52 Chinese plants with FDA inspections of the 1,046 other non-U.S. food plant inspections during the same period shows that Chinese plants have actually fared quite well (see Figure 5). Notably, the Chinese plants were twice as likely to have a “good” inspection, with the FDA requiring no action.

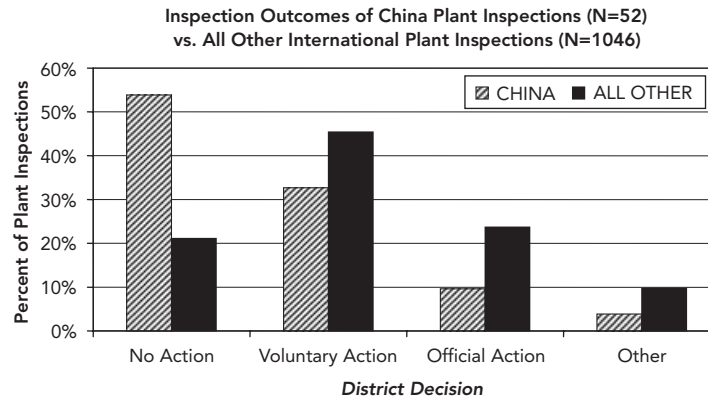
Moreover, Chinese plants were less than half as likely to receive an “official action” (OAI). A  $\chi^2$  test leads to rejection of the null hypothesis that country of plant (China vs. all others) is independent of an inspection outcome. That is to say, it appears that China did, during

this period, have significantly better inspection outcomes than the collective set of all other international food plants. Whether this means that the Chinese plants in fact had better quality, or whether it reflects the characteristics of the inspectors, the propensity for Chinese factories to circumvent compliance (Gould 2005; Wong 2007), etc., cannot be determined from these data. A qualifying factor is that the inspections in China during this period were concentrated in the two specific years, 1998 and 2005, which were the years foreign FDA inspections tended to result in fewer “official actions” and more “no actions” than the other years in this time frame.

While the relatively strong inspection results may be comforting to consumers, our evaluation of the enforcement reports on the FDA website is unsettling. We found that numerous recalls of Chinese-made food products have involved Chinese plants that were *not* inspected by the FDA — at least not inspected during the period 1998–2005. This finding indicates that a significant amount of food is entering the U.S. from mainland Chinese facilities that have never been subjected to a single FDA inspection. To make matters worse, the probability that this food will be inspected at U.S. ports is quite low. The FDA inspects only about 1 percent of the incoming food over which it has jurisdiction (Burros 2007), and it does not inspect for nonorganic contaminants such as heavy metals that may be present in produce, dietary supplements (e.g., vitamins, minerals and amino acids), and fish due to pollution (Bridges 2007; Pugh 2007). Also, food traders know which ports of entry are less likely to have FDA inspections, and food originating in China may be channeled through countries whose food products are less apt to be inspected (Burros 2007). Thus, relying solely on the FDA to ensure U.S.

<sup>1</sup>These data were obtained through a Freedom of Information Act (FOIA) request to the FDA. See Gray et al. (2007b).

**FIGURE 5**  
**Comparison of FDA Food Inspection Outcomes: Chinese and Other: 1998–2005\*.**



\*Note: Only FDA-inspected plants are included. Reports on the FDA website found that numerous recalls of Chinese-made food products have involved Chinese plants were *not* inspected by the FDA during the period 1998–2005.

food safety is especially risky, given the rising trajectory in food imports from China and other emerging market countries where standards, regulation, compliance and enforcement are spotty at best (Zhang 2007).

## TOWARD AN UNDERSTANDING OF CHINESE FOOD SUPPLIERS

As China's role in the global economy has exploded, so has the amount of literature providing advice on how to navigate the cultural and environmental challenges that can arise in doing business with Chinese organizations (see, for example, Campbell, Hexter and Yin 2004; Handfield and McCormack 2005; Quint and Shorten 2005; Zhao, Flynn and Roth 2006, 2007; Lee and Lee 2007). Much of this has focused on the sourcing of goods or services from China. The body of advice acknowledges the many difficulties for outsiders in conducting business within a deeply entrenched culture with an elaborate set of unwritten rules, practices and customs, especially as it undergoes lightspeed changes and faces the inevitable growing pains. The current Chinese business environment has been likened to the opening of the American Wild West (e.g., Mihm 2007) — a vast area of opportunity with many uncharted and risky paths, governed by a legal system that is still a work in process.

Our goal in this section is to concisely present certain conventions of the traditional Chinese business environment, ideology and culture that specifically illuminate the practices of Chinese food suppliers. We note in advance the inherent limitations of any behavioral generalizations about a nation consisting of more than 1.3 billion people and dozens of ethnic groups, who are spread out over a land mass roughly the same size as the United States. Further, we make no claims that any of these individual factors are unique to mainland China.

## Views Related to Money

Modern Chinese culture does not have the same degree of ambivalence toward money and wealth that is common in many Western capitalist societies. Financial matters are unapologetically overt — placed front and center in daily life. Deng Xiaoping, whose regime spanned the 1970s through the 1990s, famously promoted the principle “致富光荣” (zhì fù guāng róng) or “To get rich is glorious,” giving governmental blessing to the Chinese admiration of wealth and earning prowess. Xu (2002) notes, “The popular saying of modern China is — money talks. Over the past decade, this saying accurately reflects the values of modern Chinese people; money doesn't always work, but nothing works without it.” Two related maxims convey the individual's drive for personal fortune: “人为财死，鸟为食亡” (rén wéi cái sǐ, niǎo wéi shí wáng) or “People die for money, birds die for food” and “有钱能使鬼推磨” (yǒu qián néng shǐ guǐ tuī mò) or “With money you can get a devil to work the grindstone” (Yang 2004, p. 473). A recent study by Peking University researchers suggested that even when Chinese people publicly express negative feelings toward the wealthy class, privately they tend to aspire to personal wealth (Zhou and Wang 2007).

We do not intend to suggest that Chinese organizations are any greedier or more disrespectful of the law than are organizations in America or other countries. Indeed, the United States was fairly recently the venue of the corporate scandals that begat the Sarbanes-Oxley Act. Rather, on behalf of the plethora of Chinese managers and workers who value integrity above money, we are encouraging a deep investigation of the structural flaws that have enabled errant supply practices to occur in China.

Despite rapid growth and industrialization, making money is difficult in the current competitive environment. China's cities contain an estimated 30 million



unemployed and countless transient workers. The situation appears to be even worse for the 900 million people living outside urban centers (Jiang 2004). Overpopulation has created cut-throat competition for any available economic opportunities. Any profitable company must regularly fend off hordes of copycats that will undercut its price. Even though a segment of Chinese society seems to be getting rich quickly, the rank-and-file workforce toils long hours for modest wages and possibly no health or welfare benefits. In fact, while wages are rising in the aggregate, for many the cost of living is rising even more quickly (Knowledge@Wharton 2006; Piboonanasawat 2007).

One popular sentiment is that in China's ultracompetitive business environment, company survival is simply impossible without breaking some rules. Midler (2007) observes, "Importers most often go to the cheapest supplier, so the supplier who quotes low and quietly cuts corners on quality is the one who wins." This is consistent with empirical research indicating that low cost dominates supply managers' outsourcing decisions (Gray, Roth and Tomlin 2007a). Some suppliers might justify their own questionable behaviors because of perceived inequities in the way that profits are shared among the parties in the supply chain. As Fallows (2007) notes, less than 10 percent of what American customers ultimately pay for the end product actually ends up in China. Viewing such actions as a matter of lax morality or greed on the part of the Chinese would be unproductive. Those factors might play a role, but a more constructive viewpoint is one that is sensitive to the degree of economic desperation that sometimes underlies these behaviors.

Because money is so difficult to earn, the Chinese are very cost conscious in their spending. They are relatively new to the idea of paying for attributes that do not have immediate and concretely perceivable impact — including process integrity concepts like traceability and transparency. This thinking appears among Chinese consumers, who put pricing pressure on Chinese manufacturers, as well as in the supply managers who make procurement and supply chain decisions for these companies. Likewise, the export market incessantly pressures Chinese companies for low prices, even while surging demand has an inflationary impact on the costs of inputs, notably food items such as meats and eggs (Piboonanasawat 2007). All this leads to an obsession with keeping costs low and helps to explain Chinese companies' swapping out of approved ingredients for cheaper substitutes or skimping on proper handling. These are examples of a phenomenon termed "quality fade," which Midler (2007) defines as the situation in which suppliers quietly cut corners on products once an export relationship is safely underway in order to fatten their own margins, figuring that there will be no real consequences in the short term.

### **Conditions Creating a Short-Term Business Mindset**

The pursuit of wealth and profit is not by itself a problem. The problems arise when that pursuit takes on an overly short-term orientation and is not held in check by market or regulatory forces, resulting in noncompliance with laws and standards, and even corruption (Roberts 2003; Gould 2005; Roberts and Engardio 2006; Wong 2007).

Midler (2007) attributes certain suppliers' opportunism to the unpredictability of China's current macro political and economic environment. A buying organization enables these behaviors by keeping the supplier's identity hidden, which is intended to prevent competitors from poaching a qualified supplier and perhaps to prevent end customers from knowing that sourcing from China is occurring at all. Supplier anonymity, coupled with the custom of collecting full payment from buyers up front and the difficulty of taking legal action, means that opportunistic behavior may have little short-term consequence for the Chinese supplier. Further, because outsiders often use local intermediaries instead of engaging with Chinese suppliers directly, the buyer-supplier relationship may in fact be a short-term transaction. Consequently, the suppliers' concerns about maintaining long-term goodwill would be directed more toward the middleman than the buying client; and the end consumer in the supply chain may not be considered at all.

Beyond export practices, there seems to be some indication that Chinese organizations still lack a long-term perspective in their business thinking. A recent poll of business executives in China found that "an overwhelming proportion of them do not understand the benefits of responsible corporate behavior, such as environmental protection, or consider the requirements too burdensome" (Economy 2007). At first glance, this short-term mindset may seem to be at odds with the conventional wisdom about Asian cultures in general and Chinese culture in particular. Several factors provide insight into a possible resolution of the apparent contradiction between Chinese people's reputation for having a long-term orientation (see, e.g., Hofstede 2007) and the surge of what can clearly be described as opportunistic supplier behaviors. A willingness to endure lengthy hardship does not by itself preclude taking the quickest path to success if the opportunity presents itself, especially when the current social uncertainty has broken the link between short-term sacrifice and long-term business success. And although the traditional Confucian element of Chinese culture contains a general moral ethos and a specific opposition to corruption and materialism, the philosophy's influence over business decision making seems to be in decline (Woodbine 2004; Fan 2007).

### **Views about Food Hygiene and Safety**

The average Chinese person's acceptable level of food hygiene is lower than that of the typical Westerner. One



reason for this is economic. While some pockets of China are enjoying unprecedented prosperity, much of the nation has very recently been or still is in survival mode, making issues like traceability or transparency something of a luxury. Those who come out of this kind of austerity, especially if they also do not have much formal education, cannot be blamed for assuming that the food and food handling methods that they survived on are sufficient. Indeed, much of the rank-and-file manpower for the food supply chains is the product of just such an upbringing in the poverty-afflicted countryside.

Economics aside, many Chinese have beliefs about human health that include a certain aversion to excessive hygiene. A folk saying, “不干不净, 吃了没病 (bù gān bù jìng, chī le méi bìng),” suggests that eating foods that are too hygienic actually weakens one’s digestive and immune systems. Some Chinese are convinced that obsession with cleanliness causes Westerners to get sick more often than Chinese people. Certainly, most outsiders would be incapacitated immediately by the bacteria in the street foods that Chinese locals regularly eat with impunity. William O’Brien, President of Hami Food of Beijing, has noted that “chilled and frozen products very often come in taxi cabs or in vans — not under properly controlled conditions” (Cha 2007, p. A01). This type of transport is not inconsistent with the way many Chinese people manage food in their own homes, commonly leaving both ingredients and meal leftovers unrefrigerated for long stretches.

Clearly, the personal views of the individual workers matter in food supply chain management, because food hygiene and safety is ultimately in their hands. Complete monitoring and supervision of workers is not feasible. In any case, it is reasonable to assume that individual workers will behave according to their personal habits and beliefs no matter what official regulations or contractual obligations might be in place. One should not assume that this necessarily reflects a deliberate intent to harm. And, as noted earlier, the prevailing mindsets may not see the value of traceability, transparency and extremely hygienic processes.

Overcoming such attitudes can require extensive training and formal process monitoring. However, such training and monitoring is less likely to be found in smaller operations. In China, 80 percent of the food producers, or roughly 350,000 enterprises, have fewer than 10 employees (Engardio, Dexter, Balfour and Einhorn 2007). A complicating factor is the high turnover in factories. The turnover rate among factory workers has been estimated to be as high as tens of percentage points per month. One reason for this is the combination of intense competition to hire skilled manufacturing workers and the workers’ readiness to jump to the highest bidder. Also, it has been suggested that the one-child-per-family policy may undermine the work ethic of

the new generation, as its members are accustomed to being the sole focus of an entire extended family’s attention. Whatever the root causes, an ever-changing workforce creates a training nightmare that influences food safety.

Some Chinese organizations have attempted to segment their domestic and international customer bases by willingness and ability to pay for food process integrity, giving each market a distinct supply chain. However, this may be prohibitively expensive to maintain, and local workers are still likely to bring in their own local standards (Dong and Jensen 2007). Ironically, China’s admittance to the World Trade Organization in 1999 may have exacerbated its food safety problems by facilitating this commingling of standards. WTO entry has allowed Chinese suppliers to serve both export and domestic markets, whereas previously suppliers could only serve either one market or the other (Lort-Phillips 2004).

### Underdeveloped Regulations and Regulatory Infrastructure

Dong and Jensen (2007) detail the highly fragmented crafting and enforcement of food regulations in China, which causes inconsistencies and coordination difficulties. For instance, the establishment of agricultural standards involves 10 different government ministries. Each level of government has developed its own standards, and there is little central coordination or enforcement. Consider the restrictions on pesticide residues: Codex Alimentarius — the international food code that is administered by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) — specifies over 2,500 maximum allowable residue levels. The developed nations are significantly more restrictive (e.g., the European Union lists over 22,000; the United States, over 8,600). By comparison, China has only 484 restrictions, and fewer than 20 percent of these conform to Codex levels. Some industries and commodities are subject to no technical standards, and there is no sound food safety law for the support and upgrading of inspections.

A regulatory infrastructure that can nurture a free enterprise society represents a delicate balancing act. It must protect the welfare of consumers, while encouraging businesses to invest and innovate by preserving the freedom to make a profit. Furthermore, it must do all this while accommodating a diverse range of beliefs, preferences and cultural norms. The United States has by no means perfected this for food or other industries, but it has had the benefit of time. The FDA has had more than a century of experience wrestling with the challenges of food safety oversight. While it is clear that Beijing is stepping up its efforts regarding food and goods safety (Calvin, Gale, Hu and Lohmar 2006; Johnson 2007), supply managers should not lose sight of the fact that China is relatively new to this game. Consequently, to

develop a food safety infrastructure comparable to that of the West, China will require more time and significantly more investments in corporate social responsibility and supplier training down to the food sources (Roberts 2003; Wong 2007).

### **Local Incentives that Favor Economic Growth over Enforcement of Regulations**

Even when existing central Chinese government policies and regulations are sound and consistent with international standards, an incentive hazard arises because enforcement is largely the responsibility of the local authorities. Roughly 70 percent of a typical local official's personal annual performance assessment is based on the GDP growth in his or her jurisdiction. This practice encourages the bolstering of local businesses with access to cheap credit, land, licenses, protection from competitors, and, most significantly, exemptions from regulations. "If local governments close all the companies that violate food safety regulations, a lot of workers will lose their jobs," says Luo Yunbo, Dean of the Food and Nutrition College at China Agricultural University in Beijing (Engardio et al. 2007).

One of the authors conducted an interview with executives of a meat processor headquartered in northeast China that corroborates many of the above points (see Appendix). This organization produces sausages and other processed meats for Chinese consumers using a vertically integrated model with many process safeguards so as to maintain visibility and control over the meat quality. As a result, the company has earned dozens of quality certifications and awards. When asked about challenges faced by the company, a manager answered that her organization wants the Chinese government to do more to enforce existing quality regulations. She explained that other organizations with questionable quality standards are undercutting this company in the marketplace, which is a problem because Chinese consumers seem to be increasingly obsessed with cost and are not willing or able to understand the importance of quality. Ironically, this company seems not that different from American firms that are facing Chinese competition.

### **Culture of Indirectness and Opacity**

Chinese culture tends to be averse to the direct acknowledgment of issues that cause embarrassment (Zhao et al. 2006). This has implications for both how companies manage difficulties internally and locally, and how the Chinese government handles problems that have escalated in scale. Unwillingness to acknowledge problems and immediately work on them contradicts modern principles for quality management, such as those of Six Sigma and lean production. Delays only allow problems to fester and spread, causing even greater cost and/or embarrassment later. Critics depict the Chi-

nese government's typical response to major problems as first denying the problem, and then blaming the foreign media for exaggeration. In the case of the melamine-laced pet food, China's General Administration of Quality Inspection vigorously denied Chinese responsibility for several weeks after the initial discovery of the problem (Manning and MacLeod 2007). The Chinese government later sought to divert attention away from the publicized problems by claiming U.S. soybean shipments to China were contaminated (Ang 2007).

To the central Chinese government's credit, some months into the crisis it assigned a highly respected official to look into ways to fix the country's issues with food and product safety (Johnson 2007; Leow and Chao 2007), which appears to have been followed by real action. For instance, as of September 2007, numerous facilities in the Shandong province, a major hub for agricultural exports, have been blocked from shipping fresh garlic and ginger until they can abide by tougher safety standards (Kesmodel and Zamiska 2007). In all fairness, every country's government has moments in which it seems to be in denial about certain problems. Certainly, one could interpret in this way the U.S. government's failure to give the FDA more resources for inspecting food imports.

## **THE SIX Ts IN FOOD SUPPLY CHAIN QUALITY MANAGEMENT**

The preceding sections have provided background for the application of our six Ts of supply chain quality management to global food supply chains, with particular attention to sourcing from China. The combination of factors identified above — ranging from the trends in modern food supply chains (e.g., globalization, consolidation and commoditization) that are driving sharp increases in imported foods and ingredients, the inability of regulators to keep pace, and the idiosyncratic aspects of culture — raises serious concern for food safety and public well-being. To mitigate these risks will require a confluence of actions buyers, suppliers, regulators and consumers regarding elements of the six Ts. Consumers are pushing food makers, distributors and retailers to ensure the safety of their food. Consumers are finding that brand does not guarantee safety. Food makers and consumers are also lobbying regulators to develop uniform standards and take more stringent actions against violators.

Yet due to the increasing complexity of global sourcing, no one group or single response can remove all the food safety risks. Supply managers must also be aware that pricing pressures can cause opportunistic behaviors on the part of suppliers and that an emphasis on inspections can actually be more costly in the long run. An alternative is to help suppliers promote and maintain food quality by sharing best practices concerning the six Ts

with their suppliers. Noting that the elements of the six Ts are highly intertwined and mutually reinforcing, we now discuss areas for practice and research regarding each of the six Ts and food supply chain issues.

### **Traceability**

Traceability was one of the first issues to be raised once the pet food recalls were underway. American consumers were dismayed at the length of time required to trace the contaminated ingredients to the country of origin and then identify their source within China. Complicating matters was the fact that FDA officials were not allowed to enter the suspected plants for weeks while their entry visas were held up (Barboza 2007).

To the extent that food ingredients are combined, processed and aggregated through a multitiered and multichannel supply chain, especially with extensive subcontracting, tracing processed foods all the way back to the source of every raw ingredient is extremely difficult. Consequently, the privately optimal level of traceability falls short of the socially desirable level. Sometimes governments deal with this market failure by imposing traceability requirements. Other times, perhaps to avoid government intervention, industry groups develop systems for third-party verification of safety, quality and credence claims. However, the efficacy of these systems in complex supply chains is not well established. There is even a growing cottage industry of consultants that offer to assist Chinese companies in evading compliance audits (Gould 2005; Wong 2007).

Companies do have economic incentives to create robust traceability systems, as these can improve supply management, increase safety and quality control, facilitate the selling of high-margin credence attribute products, and reduce the likelihood of expensive and embarrassing recalls. Motivated by incidents of tainted food in Europe, French hypermarket chain Carrefour created Quality Line products, supplied by local farmers who agree to meet tough quality standards. The products are now offered in 15 countries and are increasingly popular (Carey 2007). In the United States, consumer advocate groups are pushing Congress for legislation requiring country-of-origin labeling on product ingredients. Currently, only seafood currently must carry this labeling (Solomon 2007).

In practice, tracing the entire path of ingredients and products from fields to factories to grocery store shelves is a tremendous technical undertaking, requiring sophisticated markers and software. "It's a global-information management problem," says Guy A. Blissett, head of consumer products at the IBM Institute for Business Value (Carey 2007). Some food companies such as Sysco have invested in radio frequency identification devices (RFID) for product tracking. However, from our observations in the field, it is clear that many other food manufacturers continue to be slow to adopt these state-

of-the-art operations and information systems practices. Future research in traceability should investigate the consumer behavior implications of country-of-origin labeling and develop approaches for combination and aggregation that can preserve traceability. It is difficult to imagine that the advantages to buying organizations of masking the identities of their suppliers would outweigh the disadvantages in the long run, but little is known about the trade-offs. Clearly, social and technical issues regarding traceability are an area for future research, as are its added costs in global supply chains versus more localized ones.

### **Transparency**

Food supply chain transparency is typically very low in emerging markets such as China. China's supply base for food ingredients is highly fragmented, consisting of some 300 million farmers, many working on farms of two acres or less and earning less than \$200 per year (Cha 2007, National Bureau of Statistics China 2006). Many of the transactions with these farmers are cash-based, leaving few paper trails. The lack of information technology and captured knowledge causes the trail to get murkier with each hand-off along the supply chain; and it opens the door for deception and other opportunistic behaviors. Maintaining physical transparency of documents, information, and goods across an ocean, and possibly across multiple ports of entry, is a significant challenge — especially given management practices that lower transparency, such as smuggling, double record-keeping and the coaching of workers to give untruthful responses during inspections (Gould 2005; Roberts and Engardio 2006; Wong 2007). Obtaining visibility into production practices at the source for food products is even more difficult. For example, determining the amount and type of contaminants in fruits, vegetables and meats requires characterizing the conditions (e.g., type of fertilizers, animals feeds, seeds, etc.) at the point of origin, which is often impossible to do after the fact.

Previous research has examined behavioral transparency, conflict and cooperation in the supply chain using game theory (Parkhe 1993), social network theory, the resource-based view of the organization, and contingency theory. According to unfolding theory (Ippolito and Mathios 1990), companies that are not transparent or that produce very little information about "negative attributes" (e.g., those that do not disclose the country-of-origin for their products) may eventually face the requirement of competitive disclosure with explicit claims for all positive aspects of the product such as "ingredients sourced in the United States." This seems to be transpiring relatively quickly, as companies not sourcing from China are starting to benefit from the new awareness of the lack of transparency in Chinese food production. In fact, certain U.S. food companies have now seized the opportunity to proactively highlight that

their products are “Not Made in China.” Upscale grocers like Fairway in New York and Whole Foods proclaim to customers that *none* of their fresh seafood comes from China. In the vitamin C category, where 80 percent of the world’s supply now comes from China (Carey 2007; Halliday 2007), DSM Nutritional Products is marketing its new Scotland-produced “premium” Quali-C brand for twice the price of bulk vitamin C.

Research questions include the following: Will a “China penalty” persist as buying organizations and end consumers continue to assume that proper practices are not being followed there? If so, what strategy should organizations pursue to provide “safe” food products at the lowest cost to consumers who are not affluent, educated, or concerned enough to care about these issues? How will behavioral, public health, technological, regulatory and economic factors affect the need for greater transparency?

### **Testability**

Relative to hard goods (e.g., electronics), where oftentimes a reasonably straightforward test procedure can be applied to 100 percent of the product, food does poorly with respect to the testability construct. One reason for this is that food inspections are generally destructive. Also, testing for the myriad things that can go wrong with food is impractical. Take, for example, contaminations by foreign substances not previously encountered. As long as a contaminant does not affect the characteristics subject to explicit testing, tainted products can easily pass along the supply chain. In addition to contamination risk, minor deviations or changes in food production processes can lead to problems with stability, shelf life, etc., that simply cannot be detected during normal testing at the production source. Even if food passes inspection at the factory, new problems can arise in transit, which might be discovered only when a critical number of end users experience problems. The poor testability of food is particularly troubling in light of the prospect of deliberate exploitation of shortcomings in known testing regimens. Future research could address the circumstances under which the testing and inspection of food products might be more effective than improving traceability, such as implementing additional training or working with more trusted suppliers that comply with guidelines.

### **Time**

We identify three types of time constructs that are relevant to supply chain quality management: (1) time in transit, (2) time between the discovery and reporting of problems and (3) time for recovery from supply disruptions. The transit time for food is particularly critical to freshness and quality. Longer lead times spent in transit and in ports waiting for entry are common in global supply chains. These delays oftentimes necessitate the

addition of chemicals to food stocks (e.g., preservatives and dyes, which sometimes turn out to be unsafe). Frozen food is more prone to spoilage and shelf life is reduced with longer transit times.

Furthermore, the inherent complexity of global supply chains increases the slowness in reporting and auditing for compliance, which often exacerbates reporting problems and operational risks. In the pet food crisis, it took weeks to identify melamine as the culprit. This was due to poor traceability, delays among intercountry agencies and the silence of Chinese wheat gluten producers regarding their unauthorized use of melamine. While not immune to food safety problems, industrialized countries typically disseminate recall instructions more quickly. Finally, although robust supply chains may recover from disruptions quickly, this is typically not the case when food stocks for many different brands originate from just a handful of large contract manufacturers. After the pet food recalls, broad shortages and empty shelves at retailers resulted from the problems experienced by the contract manufacturer Menu Foods, which was a supplier for nearly 100 different pet food brands (Byron 2007).

The role of time can be investigated from several perspectives. What are the different time-based strategies for improving reporting and response? What is the overall impact of these strategies on the organization’s short-term and long-term performance? Time also plays a key role in research on when it is best for firms to use local instead of global supply chains. For instance, local food enjoys reduced time in transit but is available only when the food is in-season (e.g., domestic oranges are available in the United States in winter only).

### **Trust**

The chain of trust from suppliers to producers to distributors to wholesalers to retailers to end users is a major topic in the general literature on buyer–supplier relationships (e.g., Johnston, McCutcheon, Stuart and Kerwood 2004; Liker and Choi 2004). The establishment of trust is a key objective when traceability and transparency are difficult to achieve. Trust is of paramount importance for the food supply chain because of the infeasibility of complete testing. In the food industry, as in others, one strategy for safeguarding quality is investment in long-term relationships with trustworthy suppliers, rather than chasing lower prices by constantly putting contracts out for bidding. Of course, having a long-term relationship does not obviate the need for audits and oversight. In fact, mutual agreement on the importance of such safeguards and the ability to cooperate in their implementation both contribute to the development of trust. Newman’s Own Organics, for example, like many buyer organizations, regularly visits its suppliers’ processing plants. The company also contracts with an independent organization that inspects and grades each production

facility (Henderson 2007). Other means to the development of trust within supply chains include certification programs, government oversight, shared values and reciprocity in benefits.

The food industry currently features dozens of product certifications intended to build consumer trust, including sustainable, organic and other practice-based campaigns (e.g., salmon-safe, humane animal treatment, fair trade, etc.). These programs emerged in parallel with the growth in consumer demand for quality, diversity and availability of locally produced products. Like their counterparts in other internationally traded product industries, such as forestry, fisheries, consumer electronics and household appliances, food certification programs provide an alternative to purely market or regulatory mechanisms in the global marketplace. The efficacy of certification is known to depend on factors that include the program's origins, the reliability of the certifying bodies and auditors, the perceptions of corruption in the industry and other issues of legitimacy (Carter 2000; Vertinsky and Zhou 2000; Raines 2003).

Previous research has examined the impact of regulation and corporate social responsibility on supplier relations. For example, Handfield, Walton, Seegers and Melnyk (1997) found that government regulation can positively influence environmental supply chain management initiatives. While many argue that government regulations are required to ensure a trustworthy supply chain, others insist that market forces and internal drivers such as organizational culture and individual values of supply managers encourage corporations to address socially responsible global practices (Roberts 2003; Carter and Jennings 2004; Wong 2007). After being informed of a pollution problem at a plant of one of its suppliers, Wal-Mart, "which recently launched a slew of initiatives in the United States to show its commitment to the environment, immediately sent a team of inspectors to the plant and canceled all direct orders with the factory" until a new waste-water treatment facility was certified by the provincial authorities (Spencer 2007, p. A12). In contrast, other multinationals have assumed a more passive posture, waiting for the Chinese government to take a greater role in regulatory enforcement.

A major obstacle to building a chain of trust in a global supply chain is the lack of shared values. As noted earlier, Westerners and Chinese have different sensibilities about food safety and hygiene, and they differ in their willingness to pay for intangible attributes of process integrity. Growers of food in the developing world do not clearly understand the concept of consumers' seeking out "organic" food. The food in developing nations often ends up organic as an incidental result of traditional local practices and the high cost of artificial fertilizers and pesticides. Conversely, many Chinese products are falsely labeled as organic (Tschang 2007).

Open questions include the following. Where is certification currently working well in supply chains? What aspects of certification, auditing and inspection efforts in other industries are most easily transferable to the food industry? Does certification truly provide an organization with a competitive advantage? How much traceability, transparency and testability are necessary and/or sufficient for certification programs to be effective? To what extent can (or should) multinational buying organizations such as Wal-Mart "flex their muscles" and mandate responsible behavior on the part of their suppliers down to the food and ingredient sources? How does this mesh with these buying organizations pressuring their suppliers for ever-lower prices? Under what conditions, if any, can cultures that do not share the same values build trust around these types of quality practices?

### **Training**

As supply chains become increasingly global, they pass through ever-broader ranges of educational levels and culturally determined behaviors. Training that includes technical assistance and the transfer of best practices is urgently necessary to bridge the gap between local norms and international expectations. Here again, the pet food recalls highlight the challenges that remain in ensuring the safety of the food supply chains. While some of the tainted food was deliberate, the investigations revealed that the same melamine, which was added to boost apparent protein levels in the pet food, is also widely used in China as a fertilizer. Melamine has been found there in livestock feed for hogs, and it is sincerely believed by the Chinese to pose "minimal" health risk to the hogs or to people who eat that pork (Cha 2007). Many Chinese farmers also are not highly educated in the use of fertilizers, and they sometimes use pesticides and other chemicals, such as DDT, that are banned in the United States in order to improve crop output and labor productivity. The U.S. Department of Agriculture has reported that China ranks among the highest users of fertilizer per hectare (Calvin et al. 2006). Given the multitude of complex social and economic factors that underlie the decision making of Chinese farmers, factory workers and managers, it is unclear whether training alone without significant Chinese government interventions and consistent enforcement of regulations will be enough to affect significant change. However, we have found no concrete evidence that improvements will occur without it.

Training must not be limited to the supplying side; supply managers need it as well. The concepts of "learning-by-doing" and "forgetting-by-not-doing" are well established in the extant operations management and strategy literatures (Argote 1999) and identify a key risk of any form of outsourcing. Maintenance of buying organizations' detailed "tribal knowledge" (Siemens, Balasubramanian and Roth 2007) is critical to the

avoidance of opportunism by suppliers (Anderson and Parker 2002; Gray, Tomlin and Roth 2007) and to the designing of transparent, traceable and testable supply chains. This know-how must be reinforced by internal training and ideally the best practices will be shared within and across industries through formal and informal means (Roth 1996). A number of questions remain to be answered. In what situations is training effective in altering food supply chain practices? What factors influence (inhibit) the transfer of quality management to supply chain partners that are culturally diverse (e.g., different values, capabilities, knowledge and resources)? Will proper levels of training result from market incentive mechanisms, or is regulation necessary? Are technology solutions viable in mass education, and how can they best be implemented?

### The Six Ts: Implications for Global Food Supply Chains

While the practices and behaviors necessary for effective quality management are well established (e.g., Giffi et al. 1990; Nair 2006), executing these across organizational boundaries is known to be a challenge (Gray et al. 2007b). The various types of distance — cultural, administrative, geographic and economic (Ghemawat 2001) — that arise from the globalization of food supply chains only complicate management by the six Ts. *Traceability* and *transparency* are naturally more difficult as the various forms of distance increase. *Time* is added to the supply chain with increased physical distance. Food is inherently difficult to thoroughly *test*. Different norms and values lead to *trust* issues that are compounded by a loss of the buying firms' knowledge over time. *Training* may be difficult because of differences in cultural norms — norms which are required to maintain supply managers' knowledge as well as to educate the chain of distributors and suppliers on best practices. In spite of the challenges imposed by global supply chains, successful management of the six Ts would help to ensure that high-quality food is delivered to consumers.

China faces major challenges to its agricultural productivity and ability to meet its domestic demand. These include the lack of arable land, air pollution and acid rain, rapidly deteriorating freshwater and poor soil quality due in part to industrialization and population growth. Such factors will further elevate the costs and quality risks of food imported from China (Brown 1995; Economy 2005; Calvin et al. 2006). Rising fuel costs alter the economics of global sourcing. To mitigate supplier opportunism and other supply chain risks, food makers and buying organizations might conclude that overdependence on a single country for supplies significantly increases their vulnerability. These factors will undoubtedly lead many buying firms to rethink their supply chain strategies, and, perhaps, to favor increased local sourcing and/or partial outsourcing (2007a,b).

## CONCLUSIONS

Over the past year, a sense of urgency in food supply chain management has resulted from revelations of the quality problems associated with foods and ingredients imported from China. Our research suggests that food-related quality risks are increasing rapidly, in part because of the ongoing acceleration in volume of importing activity, the inherent complexity of global sourcing, and the limited capacity of existing regulatory bodies to police these product flows. This study is one of the first to holistically examine quality issues for globally sourced foods using a supply chain management perspective. The supply chain management problems are especially challenging for food products because of their intrinsic characteristics and the trade-offs that need to be made regarding availability, perishability and variability in supply and quality. Global sourcing and outsourcing of production have increased with the opening of nontraditional markets. Yet the buyer-supplier issues in food sourcing and safety, especially in emerging-market countries such as China, have not received much scrutiny in the operations and supply chain academic literatures, despite their importance to public well-being, safety and security.

We have used information on recent recall events and the results of our pilot investigation on food supply chains as a substrate for the development of a blueprint for quality improvement along six key elements that we call the six Ts of supply chain quality management — traceability, transparency, testability, trust, time and training. These Ts are highly interrelated and mutually reinforcing. If we consider food supply chain quality improvement as a Six Sigma project, the six Ts represent the key necessary inputs and outputs of the DMAIC approach. We have described how current cultural and business conditions, lack of enforceable global standards and buying organization pressures may motivate some Chinese suppliers to cut corners with respect to food safety, and thereby to create difficulties for management according to the six Ts principles.

A major contribution of this paper is to bring to the forefront the critical challenges posed by the global sourcing of food and to provide an agenda for further discussion and research regarding global food supply chains. We have presented a number of research themes and open questions, the contemplation of which can improve practice. Popular solutions that depend on regulatory inspections, third-party auditing for compliance and testing among entities in complex food global supply chains are costly and cannot alone ensure food safety. Thoughtful readers will recognize that the solution space is nontraditional for most supply chain professionals in that it requires consideration of not only the technical facets of food supply chains (e.g., logistics, information systems, food science, etc.) but also social, political, legal, economic, cultural and ethical factors.

## REFERENCES

- Anderson, E.G. and G.G. Parker. "The Effect of Learning on the Make/Buy Decision," *Production and Operations Management*, (11:3), 2002, pp. 313-339.
- Ang, A. "China, on the Defensive Over Product Safety, Says U.S. Soybean Exports Tainted," *The Associated Press*, August 22, 2007.
- Argote, L. *Organizational Learning: Creating, Retaining, and Transferring Knowledge*, Kluwer, Dordrecht, 1999.
- Barboza, D. "Chinese Executive Held in Inquiry of Tainted Pet Food," *The New York Times*, May 4, 2007, p. 2.
- Bridges, A. "Imported Food Rarely Inspected," *USA Today.com*, April 16, 2007. [http://www.usatoday.com/news/nation/2007-04-16-imported-food\\_N.htm](http://www.usatoday.com/news/nation/2007-04-16-imported-food_N.htm). Accessed September 30, 2007.
- Brown, L.R. *Who Will Feed China? Wake-up Call for a Small Planet*, W.W. Norton & Company, New York, 1995.
- Burros, M. "FDA Inspections Lax, Congress Is Told," *The New York Times*, July 18, 2007, p. 3.
- Byron, E. "101 Brand Names, 1 Manufacturer; The Mass Pet-Food Recall Reveals a Widespread Practice: Many Competing Products Come from the Same Factory," *The Wall Street Journal*, May 9, 2007, p. B1.
- Calvin, L., F. Gale, D. Hu and B. Lohmar. "Food Safety Improvement Underway in China, Economic Research Service," *Amber Waves*, U.S. Department of Agriculture Report, November 2006, pp. 17-21.
- Campbell, R.M., J. Hexter and K. Yin. "Getting Sourcing Right in China," *McKinsey Quarterly*, Special ed., 2004, p. 34.
- Carey, J. "NOT Made In China," *Business Week*, July 30, 2007, pp. 41-43.
- Carter, C. "Ethical Issues in International Buyer-Supplier Relationships: A Dyadic Examination," *Journal of Operations Management*, (18:2), 2000, pp. 191-208.
- Carter, C. and M. Jennings. "The Role of Purchasing in Corporate Social Responsibility: A Structural Equation Analysis," *Journal of Business Logistics*, (25:1), 2004, pp. 145-186.
- CDA (Center for Disarmament Affairs). *United Nations Disarmament Yearbook*, U.N. Publication Sales, New York, volume 17, 1992.
- Cha, A.E. "China Food Fears Go from Pets to People," *The Washington Post*, April 25, 2007, p. A01.
- Dong, F. and H.H. Jensen. "Challenges for China's Agricultural Exports: Compliance with Sanitary and Phytosanitary Measures," *Choices*, (22), 2007, pp. 19-24.
- Economy, E.C. *The River Runs Black: The Environmental Challenge to China's Future*, Cornell University Press, Ithaca, NY, 2005.
- Economy, E.C. "The Great Leap Backward?," *Foreign Affairs*, (86:5), 2007, pp. 38-59.
- Engardio, P., R. Dexter, F. Balfour and B. Einhorn "Broken China," *Business Week*, July 23, 2007: pp. 38-45.
- Fallows, J. "China Makes, the World Takes," *The Atlantic Monthly*, (300), 2007, pp. 48-72.
- Fan, M. "Confucius Making a Comeback in Money-Driven Modern China," *Washington Post*, July 24, 2007, p. A01.
- Farah, J. "China Products Choke, Burn, Drown, Drop, Trap Americans," [http://www.wnd.com/news/article.asp?ARTICLE\\_ID=56063](http://www.wnd.com/news/article.asp?ARTICLE_ID=56063), Accessed June 11, 2007.
- Ghemawat, P. "Distance Still Matters. The Hard Reality of Global Expansion," *Harvard Business Review*, (79:8), 2001, pp. 137-147.
- Giffi, C., A.V. Roth and G.M. Seal. *Competing in World-Class Manufacturing: America's 21st Century Challenge*, Business One Irwin, Homewood, IL, 1990.
- Gogoi, P. "Wal-Mart's Organic Offensive," [http://www.businessweek.com/bwdaily/dnflash/mar2006/nf20060329\\_6971.htm](http://www.businessweek.com/bwdaily/dnflash/mar2006/nf20060329_6971.htm), Accessed September 22, 2007.
- Golan, E., B. Krissoff, F. Kuchler, L. Calvin, K. Nelson and G. Price. *Traceability in the U.S. Food Supply: Economic Theory and Industry Studies*. Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 830, 2004.
- Gould, D. "The Problem with Supplier Audits," *Corporate Responsibility Management*, (2:1), 2005, pp. 24-29.
- Gray, J.V., A.V. Roth and B. Tomlin. "Antecedents of Decisions to Outsource Production: A Manufacturing Strategy Perspective." Ohio State University Working Paper, 2007a.
- Gray, J.V., A.V. Roth and B. Tomlin. "Quality Risk in Outsourcing: Evidence from the U.S. Drug Industry," Ohio State University Working Paper, 2007b.
- Gray, J.V., B. Tomlin and A.V. Roth. "The Effect of Power and Path-Dependencies on Manufacturing Outsourcing Decisions," Ohio State University Working Paper, 2007.
- Halliday, J. "Cut Costs to Beat Asia, Euro Vitamin Makers Take Hold," <http://www.nutraingredients.com/news/ng.asp?n=62689-dsm-basf-vitamin-c-production-costs>, Accessed September 21, 2007.
- Hamprecht, J., D. Corsten, M. Noll and E. Meier. "Controlling the Sustainability of Food Supply Chains," *Supply Chain Management*, (10:1), 2005, pp. 7-10.
- Handfield, R.B. and K. McCormack. "What You Need to Know About Sourcing from China," *Supply Chain Management Review*, (9:6), 2005, pp. 28-36.
- Handfield, R.B., S.V. Walton, L.K. Seegers and S.A. Melnyk. "'Green' Value Chain Practices in the Furniture Industry," *Journal of Operations Management*, (15:3), 1997, pp. 293-315.
- Hayward, G. and R. Nolan. *Grocery Management and Operations*, Cornell University, Ithaca, NY, 1990.
- Henderson, D. "Pet Food Makers Working to Bring Trust Back to the Table," *Boston Globe*, May 22, 2007.
- Hofstede, G. Geert Hofstede Cultural Dimensions (China), [http://www.geert-hofstede.com/hofstede\\_china.shtml](http://www.geert-hofstede.com/hofstede_china.shtml), Accessed August 25, 2007.
- Hosmer, L. "Trust: The Connecting Link between Organizational Theory and Philosophical Ethics," *Academy of Management Review*, (20:2), 1995, pp. 379-403.



- Howard, P. "Organic Industry Structure," <http://www.marketsharematrix.org/pdf/OrganicJune05.pdf>, Accessed September 21, 2007.
- Ippolito, P. and A. Mathios. "The Regulation of Science-Based Claims in Advertising," *Journal of Consumer Policy*, (13), 1990, pp. 413-445.
- Jarosz, L. "Understanding Agri-food Networks as Social Relations," *Agriculture and Human Values*, (17:3), 2000, pp. 279-283.
- Jiang, W. "Prosperity Based on Poverty and Disparity," *China Review Magazine*, Issue 28, Spring, 2004.
- Johnson, I. "Beijing Steps Up Battle for Quality," *The Wall Street Journal*, September 7, 2007, p. A6.
- Johnston, D.A., D.M. McCutcheon, F.I. Stuart and H. Kerwood. "Effects of Supplier Trust on Performance of Cooperative Supplier Relationships," *Journal of Operations Management*, (22:1), 2004, pp. 23-38.
- Kastel, M. *Maintaining the Integrity of Organic Milk*, Cornucopia Institute Research Report, Cornucopia, WI, 2006.
- Kesmodel, D. and N. Zamiska. "China Curbs Garlic, Ginger Exports to the U.S.," *The Wall Street Journal*, September 18, 2007, p. D7.
- Knowledge@Wharton. *Analyzing the Labor Shortage in China*, Knowledge@Wharton, Philadelphia, 2006.
- Lee, H.L. and C.Y. Lee. *Building Supply Chain Excellence in Emerging Economies*, International Series in Operations Research & Management Science, Issue 98, Springer, New York, 2007.
- Leow, J. and L. Chao. "China Shows Concern Over State of Export Recalls," *Wall Street Journal*, August 18, 2007, p. A3.
- Liker, J.K. and T.Y. Choi. "Building Deep Supplier Relationships," *Harvard Business Review*, (82:12), 2004, pp. 104-113.
- Lort-Phillips, L. "Ethical Trade in China: One Country, Two Systems?" *China Review Magazine*, Issue 27, Winter, 2004.
- Maloni, M.J. and M.E. Brown. "Corporate Social Responsibility in the Supply Chain: An Application in the Food Industry," *Journal of Business Ethics*, (68:1), 2006, pp. 35-52.
- Manning, A. and C. MacLeod. "China Denies Role in Pet Food Recall," [http://www.usatoday.com/news/world/2007-04-02-china-pet-food\\_N.htm](http://www.usatoday.com/news/world/2007-04-02-china-pet-food_N.htm), Accessed September 21, 2007.
- Midler, P. "'Quality Fade': China's Great Business Challenge," *Knowledge@Wharton*, July 25, 2007.
- Mihm, S. "A Nation of Outlaws: A Century Ago, That Wasn't China — It Was Us," *The Boston Globe*, August 26, 2007.
- Nair, A. "Meta-analysis of the Relationship between Quality Management Practices and Firm Performance — Implications for Quality Management Theory Development," *Journal of Operations Management*, (24:6), 2006, pp. 948-975.
- National Bureau of Statistics China, *China Statistical Yearbook*, China Statistics Press, 2006. <http://www.stats.gov.cn>.
- Parkhe, A. "Strategic Alliance Structuring: A Game Theoretic and Transaction Cost Examination of Interfirm Cooperation," *Academy of Management Journal*, (36:4), 1993, pp. 794-829.
- Piboonanasawat, N. "China's Inflation Rate Jumps to Highest in 10 Years," <http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a.IqJUBWKVGE>, Accessed September 21, 2007.
- Prahalad, C.K. and G. Hamel. "The Core Competence of the Corporation," *Harvard Business Review*, 1990, pp. 79-90.
- Pugh, T. "FDA Sorely Lacking In Supplement Inspections," *San Diego Union-Tribune*, June 3, 2007. [http://www.signonsandiego.com/uniontrib/20070603/news\\_1n3fdavita.html](http://www.signonsandiego.com/uniontrib/20070603/news_1n3fdavita.html). Accessed September 30, 2007.
- Quint, M. and D. Shorten. "The China Syndrome," Booz, Allen, and Hamilton, *Strategy + Business Resilience Report*, 2005.
- Raines, S.S. "Perceptions of Legitimacy and Efficacy in International Environmental Management Standards: The Impact of the Participation Gap," *Global Environmental Politics*, (3:30), 2003, pp. 47-74.
- Roberts, D. and P. Engardio. "Secrets, Lies, and Sweatshops," *Business Week*, November 27, 2006.
- Roberts, S. "Supply Chain Specific? Understanding the Patchy Success of Ethical Sourcing Initiatives," *Journal of Business Ethics*, (44:2-3), 2003, pp. 159-170.
- Roth, A.V. "Achieving Strategic Agility through Economies of Knowledge," *Strategy and Leadership* (24:2), 1996, pp. 30-37.
- Saltmarsh, N. and T. Wakeman. *Local Links in the Global Supply Chain*, East Anglia Food Link, Leader + Broads Rivers Programme, Norfolk, 2004.
- Siemens, E., S. Balasubramanian and A.V. Roth. "Incentives that Induce Task-Related Effort, Helping, and Knowledge Sharing in Workgroups," *Management Science*, (53:10), 2007, pp. 1533-1550.
- Solomon, G.L. "Country of Origin: Should You Know Before You Buy?" *The Washington Post*, August 22, 2007, p. F06.
- Spencer, J. "Ravaged Rivers: China Pays Steep Price as Textile Exports Boom," *The Wall Street Journal*, August 22, 2007, p. A1.
- Story, L. "Mattel in Another Recall, Citing Lead in Toys from China," *The New York Times*, September 5, 2007, pp. 4.
- Tschang, C.C. "Organic, With Pesticides," *Business Week*, July 30, 2007, pp. 42-43.
- U.S. Census Bureau. <http://censtats.census.gov/sitc/sitc.shtml>, Accessed August 17, 2007a.
- U.S. Census Bureau. <http://www.census.gov/foreign-trade/balance/c5700.html#2007>, Accessed August 17, 2007b.
- USFDA (U.S. Food and Drug Administration). <http://www.fda.gov/oc/opacom/hottopics/petfood.html>, Accessed July 23, 2007.
- Vertinsky, I. and D. Zhou. "Product and Process Certification: Systems, Regulations, and International Marketing Strategies," *International Marketing Review*, (17:3), 2000, pp. 231-252.

- Welch, D., L.L. Woellert and J. Carey. "An Importer's Worst Nightmare; A Chinese Supplier, Safety Shortcuts, and an American Middleman under Siege," *Business Week*, July 23, 2007, pp. 46–48.
- Whole Foods. "Quality Standards: Unacceptable Food Ingredients," <http://www.wholefoodsmarket.com/products/unacceptablefoodingredients.html>, Accessed July, 2007.
- Wong, A. "Moving Beyond Supplier Auditing," *China Business Review*, May 1, 2007. <http://license.icopyright.net/user/viewFreeUse.act?fuid=NDU0NjEy>. Accessed September 29, 2007.
- Woodbine, G.F. "Moral Choice and the Declining Influence of Traditional Value Orientations Within the Financial Sector of a Rapidly Developing Region of the People's Republic of China," *Journal of Business Ethics*, (55), 2004, pp. 43–60.
- Xu, X. "Unchained Interest: Graceful Chinese Attitude towards Money Changes," *Shanghai Star*, April 4, 2002.
- Yang, L. *Cultural Restoration versus Cultural Revolution*, The Documentation and Research Centre for Modern China, Sinological Institute, Leiden University. Sage Publications, Thousand Oaks, CA, (17), 2004, pp. 463–488.
- Zhang, J. "Food Makers Get Appetite for Regulation," *The Wall Street Journal*, September 17, 2007, p. A2.
- Zhao, X., B.B. Flynn and A.V. Roth. "Decision Sciences Research in China: A Critical Review and Research Agenda — Foundations and Overview," *Decision Sciences*, (37:4), 2006, pp. 451–496.
- Zhao, X., B.B. Flynn and A.V. Roth. "Decision Sciences Research in China: Current status, Opportunities, and Propositions for Research in Supply Chain Management, Logistics, and Quality Management," *Decision Sciences*, (38:1), 2007, pp. 39–80.
- Zhou, F. and D. Wang. "Dissociation between Implicit and Explicit Attitudes Towards the Rich in a Developing Country: The Case Of China," *Social Behavior and Personality: An International Journal*, (35:3), 2007, pp. 295–302.

---

**Aleda V. Roth** (Ph.D., The Ohio State University) is the Burlington Industries Distinguished Professor in Supply Chain Management in the College of Business and Behavioral Science at Clemson University, Clemson, South Carolina. She is an internationally recognized scholar with more than 150 publications, 49 research awards, and 27 grants to her credit. She holds senior editorial positions for *Management Science*, *Production and Operations Management* (POM), *Journal of Operations Management* (JOM), *Decision Sciences* (DSJ), *Journal of Supply Chain Management* and others. She served as POMS President and is a Fellow of DSI, POMS, and the UK Advanced Institute of Management Research (AIM). She is a visiting Professor at Xi'an Jiaotong University and a Faculty Advisor for Li & Fung Institute of Supply Chain

Management at the Chinese University of Hong Kong. She is a member of the Conference Board's Performance Excellence Council.

**Andy A. Tsay** (Ph.D., Stanford University) is an Associate Professor in the Leavey School of Business at Santa Clara University, Santa Clara, California, and a Senior Research Fellow of the Global Supply Chain Management Forum at Stanford University. Professor Tsay studies the practice of design, manufacturing and procurement in heavily outsourced supply chains (e.g., in electronics, apparel and food industries). He serves as an Associate Editor of the journal, *Management Science*. His research has been published in leading academic journals such as *Management Science*, *Manufacturing & Service Operations Management*, *Production & Operations Management*, *Interfaces*, and *Journal of Retailing*, managerial journals such as *Supply Chain Management Review*, and various books on supply chain management.

**Madeleine E. Pullman** (Ph.D., University of Utah), is the Willamette Industries Professor of Supply Chain Management in the school of business, at Portland State University, Portland, Oregon. Her major research interests include new product and service creativity and design, sustainable food supply chain issues, recreation and experience design, and operations/marketing interdisciplinary issues. Her articles have appeared in various journals and periodicals including *Journal of Operations Management*, *Decision Sciences*, *Production and Operations Management*, *Journal of Service Research*, *International Journal of Service Industry Management*, *Cornell Hotel and Restaurant Administration Quarterly*, *Omega*, and *Journal of Product Innovation Management*. Her current projects of study include Innovation Process of Chef Experience Design, Sustainable Practices in the Food Processing Industry, Structuring a Sustainable Business and Reporting Model, and Sustainable Business Supply Chain: Case Study on Country Natural Beef Cooperative.

**John V. Gray** (Ph.D., University of North Carolina-Chapel Hill) is an Assistant Professor in the Fisher College of Business at The Ohio State University, Columbus, Ohio. His current research interests include quality risk in manufacturing outsourcing and offshoring; path dependencies in manufacturing outsourcing; antecedents of manufacturing outsourcing decisions; and, the effect of standards certification (ISO 9000) on quality risk. He has several projects utilizing FDA inspection data to assess quality risk in the food, drug and medical device industries. This research involves theorizing about the conditions under which plants may engage in behaviors that increase quality risk, and, testing the hypotheses. Titles of aforementioned studies include: "Quality Risk in Outsourcing: Evidence from the U.S. Drug Industry," "Offshoring's Quality Risk: A Theoretical Explanation and Empirical Evidence," "Outsourcing's Quality Risk: A Contingency Perspective," and "Does ISO 9000 certification reduce quality risk? A Retrospective Study."

## APPENDIX

---

### About This Study

This study was motivated by the recent food recalls and research that the authors were conducting on quality risk, food supply chains and outsourcing to China. The study was based on the combined research team's (1) collective research experience in quality risks, food sourcing and China; (2) active pilot research in China; and (3) a review of the literature. The team developed a short survey to guide initial discussions. The first author visited China and investigated supply chain practices and the business climate, in general, as a result of the food recalls. She informally interviewed everyday Chinese people to gain insights on their perceptions of food quality and Chinese practitioners to gain insights on the business climate regarding outsourcing and quality risk. In addition, she interviewed a number of U.S. food producers and performed online queries to gauge U.S. company and distributor responses to the recalls. The second author spent parts of spring and summer 2007 in China visiting food processing facilities and other factories. He and his research assistants interviewed managers and collected responses to the survey instrument about production, procurement and quality management practices developed by the research team. The third author has been conducting an ex-

tensive study on supply chain management for food producers in the western United States. Using surveys and interviews, she has collected data on the values and practices of companies buying food from China, other international locations, and local producers. Currently, she has gathered more than 40 in-depth interviews and 100 surveys, and her preliminary findings have added significantly to defining key issues regarding food supply chains. In addition, the first and fourth authors have a research stream which examines a manufacturer's "quality risk" in outsourcing production in FDA-regulated facilities. A database from this research stream was drawn upon to evaluate the FDA's inspections of Chinese companies reported in this paper. In this stream, the authors used the Delphi process with a panel of experts to transform raw FDA inspection data into a valid measure of plant-level quality risk. Utilizing this measure, the authors have a completed study on quality risk in outsourcing (Gray et al. 2007a), and have work underway which investigates off-shoring quality risk as well as the effect of ISO 9000 standards on quality risk. Overall, the authors' research draws from economic and organizational theories and practice to explain the drivers of quality risk when sourcing from emerging markets like China.