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# Quality control in food supply chain management: An analytical model and case study of the adulterated milk incident in China

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## ABSTRACT

Managing the food supply chain quality and risk has received significant attention in recent years especially in global emerging markets such as India and China. In this paper, we present a mutually supporting analytical model and exploratory case to study the managerial and policy issues related to quality control in food supply chain management with a focus on the Chinese dairy industry. Based on a general supply-chain model with acceptance sampling tests under uncertain product quality, we show that, depending on the sampling technology, the decentralized supply-chain structure may lead to a distortion in product quality. We also explore the effects of different pricing and regulatory options of vertical control on product quality and the distribution of the total supply-chain profit. In addition, we use an exploratory case study of the 2008 adulterated milk incident in China to investigate practical issues in ensuring product quality/safety in food supply chain management. Our analytical results and two comparative cases show that, instead of the common “poor quality” misperception of food products from global emerging markets, it is actually the poor vertical control strategy for managing the food supply chain quality and risk that caused the adulterated milk incident. A number of other important managerial and policy insights and implications regarding supply chain design, informational visibility, corporate social responsibility, and regulatory action in managing the global food supply chain quality and risk are also discussed.

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## 1. Introduction

Managing the food supply chain quality and risk has received significant attention in recent years especially in global emerging markets. For example, India has encountered a number of food safety problems in its spice exports including high pesticide residues, aflatoxin contamination, and the use of prohibited food colorants (Umali-Deininger and Sur, 2007). In 2007, Menu Foods, a Canadian pet food manufacturer and retailer, massively recalled its popular brands of pet foods which were said to cause sickness and death of pet animals. According to the company, high levels of melamine found in its pet foods, which originated in wheat gluten and rice protein concentrate imported from Chinese suppliers, were the cause of the incident, though such a claim was disputed by Chinese officials. Rightly or wrongly, these recent events have led to suppliers in global emerging markets being held mostly responsible

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for the quality and safety problems of food products distributed by multinational firms (Farah, 2007). For example, when salmonella was found in black pepper made by Daniele International in 2010, the company's two Vietnamese suppliers were quickly blamed by the Rhode Island Food Safety Authorities (FoodNavigator-USA, 2010). In the 2008 adulterated milk incident, the original response by Sanlu Group, the company whose dairy products were first detected with a high level of melamine, and Fonterra, Sanlu's New Zealand partner, was to blame the milk farmers and dealers who allegedly sold contaminated milk to Sanlu (Financial Times, 2008a). However, given the fact that most multinational enterprises today have well-established quality management systems with aids of advanced technologies for quality control, it is hard to imagine how those hazardous food products could have passed all the quality inspections along their supply chains to reach the marketplace in such a massive scale. Additionally, the pressing requirements for fast delivery and low costs imposed by multinational firms can also severely challenge a supplier's bottom line, which results in quality alteration or deterioration.

In this paper, we present a mutually supporting analytical model and case study to shed new light on the theoretical and practical aspects of managing the food supply chain quality and

risk in global emerging markets with a focus on the Chinese dairy industry. We will first develop a general theoretical model to establish key analytical results regarding quality control in food supply chain management under different market and regulatory settings, and then use a case study of the 2008 adulterated milk incident in China with two comparative cases of the centralized and decentralized approaches for supply chain quality control and risk management to further explore practical issues in order to derive important managerial and policy insights in terms of vertical control strategy, informational visibility, and regulatory action in managing the food supply chain quality and risk.

While there has been a growing number of empirical work on the quality issue in supply chain management (refer to Li and Warfield (2011) for a good characterization), there have been surprisingly fewer analytical papers on quality modeling in food supply chain management. Wang and Li (2012) use a pricing approach based on dynamically identified food shelf life with the objectives to reduce food spoilage waste and to maximize food retailer's profit. Wang et al. (2012) develop a new risk assessment approach to perform structured analysis of aggregative food safety risk in the food supply chain by using the concepts of fuzzy set theory and analytical hierarchy process. In the more general area of supply chain quality management, Yao and Zhang (2009) develop a two-stage leader-follower game theoretic model to analyze the decisions made by the buyer and supplier with a quality cost-sharing contract in a supply chain. Wu et al. (2011) study a two-tier supply chain consisting of a buyer and two competing suppliers with uncertain product qualities. Xiao et al. (2011) explores coordination of a two-tier supply chain with a revenue-sharing contract between a manufacturer and supplier. Xie et al. (2011) study quality improvement in a market segment shared by two supplier–manufacturer supply chains which offer a given product at the same price but compete on quality. Ma et al. (2013) investigate the equilibrium behaviors of a manufacturer–retailer supply chain under three supply chain structures, namely, manufacturer Stackelberg, retailer Stackelberg, and vertical Nash, and show how the retailer's profit and marketing effort and manufacturer's profit and quality-improvement effort are affected by marketing and quality costs under different settings. Liu et al. (2013) and Liu and Xie (2013) study quality supervision and coordination issues for the logistics service supply chain under multi-period conditions and a service quality guarantee.

In terms of relevant empirical or case-based studies, Roth et al. (2008) develop a conceptual framework to identify six key elements—traceability, transparency, testability, time, trust and training—which are critical to the preservation of public welfare through a safe food supply using food products originating in China as examples. The 2008 adulterated milk incident in China has been separately reported in various industry reports and articles with such focuses as business ethics (e.g., DeLaurentis, 2009; Song, 2009), agriculture economics (e.g., Hu, 2009; Gale and Hu, 2009), and actional legitimacy (Petrun and Sellnow, 2010). Lu et al. (2009) present a more comprehensive teaching case regarding corporate crisis management based on the incident. With two comparative cases of the decentralized and centralized approaches, our case study differs from those presented in the above reports and articles with a focus on food supply chain quality control and risk management. To the authors' knowledge, our paper makes significant contributions in two major aspects. First, we develop a theoretical model with general cost and valuation structures to explore the generic effects of operational, strategic, and policy issues regarding vertical control, quality testing, price-based control, and regulatory action in food supply chain quality control with uncertain product quality captured by a general distribution function (as opposed to a specific distribution function assumed in most existing models). While the effects of the wholesale and retail prices and quality-

improvement costs on product quality in supply chain management have been explored in the existing literature (e.g., Xie et al., 2011; Ma et al., 2013), our paper presents the first analytical model that identifies the effects of quality distortion due to sampling testing technology and different supply chain structures. In addition, we use comparative cases of two companies with different supply-chain structures in the 2008 adulterated milk incident in China, which was one of the largest global food safety events in recent years, to investigate key issues in food supply chain quality management as well as to extract useful managerial and policy insights which can be applied to today's global emerging markets. The remainder of the paper is organized as follows. In Section 2, we develop the analytical model. In Section 3, we present the within case analyses of the two Chinese dairy companies. The cross case analysis and managerial and policy insights are discussed in Section 4, and conclusion is in Section 5.

## 2. Analytical model

We now develop an analytical model that considers the centralized and decentralized food supply-chain structures similar to that in Tirole (1988) with additional components to capture the efforts of quality control by multiple players in a supply chain. While the model is intended to analyze the strategic and policy issues related to food quality control in supply chain management in today's global emerging markets, the examples used to describe the model specifications as well as to discuss the analytical results will be primarily based on the 2008 adulterated milk incident in China with more detailed information to be presented in the case study later in the paper. Fig. 1 illustrates the structures of the centralized and decentralized supply chains of the analytical model with the names and roles of players drawn from the case study. For the centralized supply chain, we consider an enterprise analogous to the Sanyuan Group in the case study which operated a highly integrated supply chain. For the decentralized supply chain, we consider an enterprise analogous to the Sanlu Group in the case study whose supply chain consisted of decentralized small-scale farms as the major sources of raw milk supply and third-party collection agents as the middlemen, as shown in Fig. 1. The above definitions of the centralized and decentralized supply

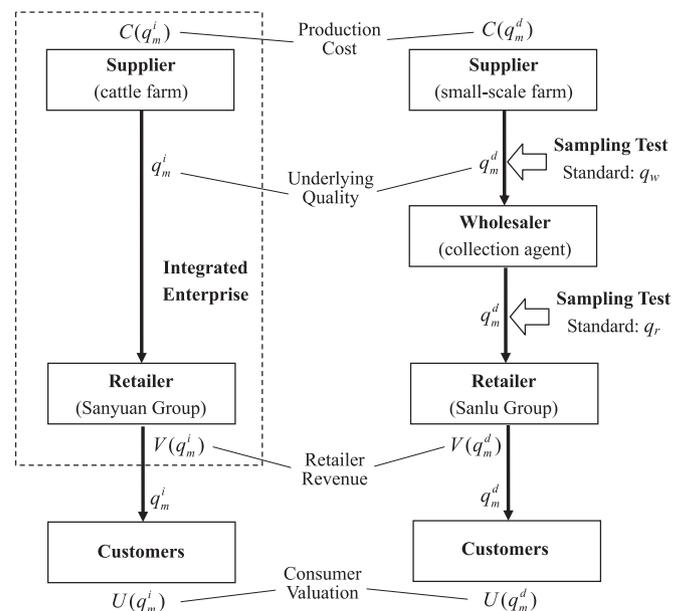


Fig. 1. Centralized supply chain (Sanyuan) vs. decentralized supply chain (Sanlu).

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