MANAGING THE "COOL CHAIN"

A Cold Chain is only as Cool as its Warmest Link

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SYNOPSIS

A *cold chain* is a supply chain in which the products moving across the supply chain are maintained in an environment that is temperature-controlled from end-to-end. A cold chain is only as strong as its "warmest" link. Many food products must be maintained at temperatures between 2 and 8 degrees Centigrade to assure freshness and safety. As products move across the food supply chain there are many opportunities for breaks that compromise this target temperature range. For example, a perishable shipment may sit in the sun for extended periods while waiting to be loaded into the cargo hold of an aircraft or ship. Increased delays en-route can reduce available shelf life. Even small deviations from this temperature range can seriously compromise shelf life and increase the rate of product deterioration.

In order to determine the vulnerabilities associated with cold chain operations between the U.S. and China, the UNC-Tsinghua Center for Logistics and Enterprise Development, performed a benchmark study of cold chain operations for a shipment of turkeys between the U.S. and China. The benchmark study was designed to better understand some of the challenges that shippers face when exporting perishable products from the U.S. to China. A number of vulnerabilities in the cold chain affect the freshness and safety of food and other perishable products. As we will see in the real world example in this case, vulnerabilities range from administrative failures to control failures to regulatory failures.

COMPLEX COLD CHAINS

More and more food and drug products that move around the globe require temperature control to maintain suitable freshness for human consumption and/or use. Many of these products—such as food, pharmaceuticals and some chemicals—can be damaged or "perish" when not kept within a specific temperature range. A number of recent food safety scares can be attributed to failures of the cold chain.

Examples of cold chain products include perishable food imports such as fresh produce grown in South America and seafood products exported from Asian countries like Thailand. Meat and dairy products are another major cold chain category. Many pharmaceuticals and vaccines must be maintained at constant temperatures to maintain viability and, thus, utility to patients who depend on them for their lives and well-being. The pharmaceutical cold chain includes other temperature-controlled products such as blood, cells and plasma, proteins, human tissues, and laboratory or clinical kits.

Unlike the U.S., many developing countries such as China do not have sufficient cold chain infrastructure. This is especially critical for food since many of the products on our grocery store shelves today have some ingredient that has been grown or processed in an emerging market country. For example, according to consulting firm A.T. Kearney, existing cold storage infrastructure in China is only seven million cubic meters compared with 88.8 million cubic meters in the U.S. A. T. Keaney also estimated that in China, for example, only about 15% of food products that should be temperature-controlled are actually handled in this way, compared with 85% in Europe and North America.

The lack of a cold chain can result in increased perishability of food products and compromised food safety—as well as considerable food waste. In many developing countries it has been estimated that without adequate cold chain infrastructure, as much as 20% to 40% of perishable food products deteriorate beyond usability before reaching their destination. For example, China's perishable freight spoilage is nearly 33% and accounts for almost USD 9 billion annually.

Providing a temperature-controlled environment is increasingly difficult because of the increasing complexity of global supply chains and because of increased outsourcing of food and drug production to countries with less well-developed cold chains. For example, shrimp from Thailand destined for dinner tables in the U.S. travel first by boat to port where they are loaded onto a truck for transport to the airport. Once on a plane, they travel across the ocean, often stopping for multiple air legs. After arriving at their destination airport, the shrimp are transferred to truck for distribution to local retail outlets.

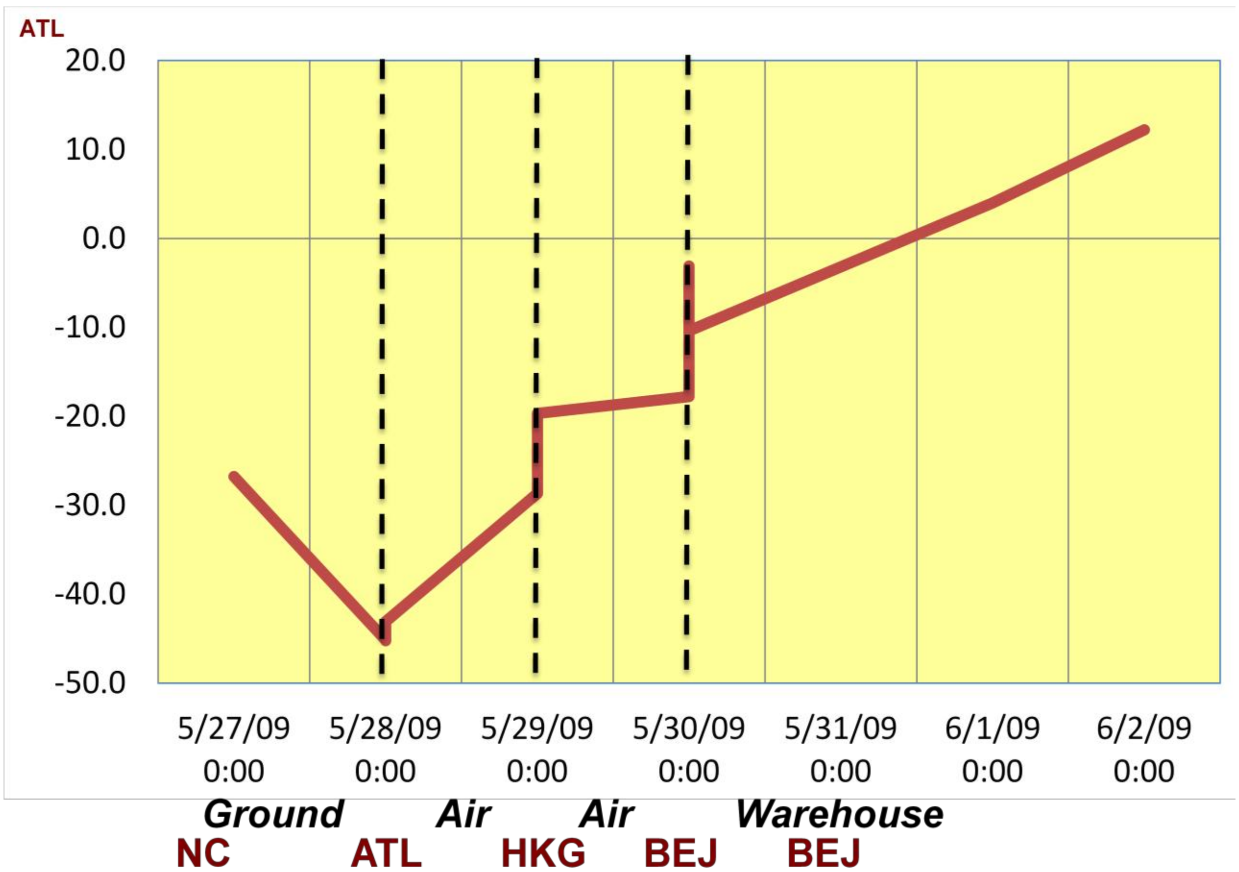
As we will see in the next section, at each point along the cold chain there are critical vulnerabilities that can lead to "breaks" in the cold chain.

BENCHMARKING COLD CHAINS

A benchmarking experiment was performed by the UNC-Tsinghua Center for Logistics and Enterprise Development in which a shipment of frozen turkeys was shipped from North Carolina to Beijing, China. North Carolina ranks #2 in the production of turkeys nationally and are a major export. The turkeys were to provide a centerpiece for a banquet at a well-known Beijing Hotel to celebrate North Carolina products. Approximately 600 pounds of frozen turkeys traveled by truck from the turkey processing plant in North Carolina to Atlanta's Hartsfield-Jackson International Airport where they were placed on an aircraft bound for Beijing with a stop in Hong Kong. By tracking the movements of the shipment from origin to destination it was possible to develop a framework for documenting and understanding the weaknesses and constraints of cold chain management processes in China.

The results of the benchmarking study are shown in **Figure 1**. Frozen turkeys should be kept at a temperature below -25°C for optimum shelf life. As shown in Figure 1, the pre-frozen turkeys left the processing plant inside a container that was maintained at an ambient temperature of approximately -26°C. By the time the turkeys arrived at Atlanta to be loaded into an air cargo container, the ambient temperature in the container had declined to -45°C. During the time that the container waited to be loaded onto the aircraft, the temperature quickly rose approximately 5 degrees. During the flight to Hong Kong, the container temperature continued to rise, returning to a temperature of -26°C—still within the target temperature range.

Figure 1: Temperature Profile for Cold Chain Benchmark Experiment



Over the remainder of the journey, the temperature in the container continued to rise. While waiting to be loaded onto another flight from Hong Kong to Beijing, the temperature rose nearly 10 degrees. Arriving in Beijing, the temperature continued to rise nearly 20 degrees above the acceptable temperature for frozen meat products. The temperature was lowered approximately 10 degrees when the shipment arrived in Beijing. However, the temperature continued its upward climb as the shipment remained unclaimed in the warehouse in Beijing.

As the turkeys remained unclaimed for three days in the warehouse, the turkeys thawed becoming unfit for consumption and had to be disposed. When the benchmarking experiment ended, the shipment temperature exceeded 10°C.

IDENTIFYING COLD CHAIN VULNERABILITIES

This failure of the frozen turkey cold chain can be attributed to a number of individual failures, as can be seen in **Figure 2**. These problems ranged from administrative failures to control failures to regulatory failures. All are characteristic of the vulnerabilities that cold chain shipments confront.

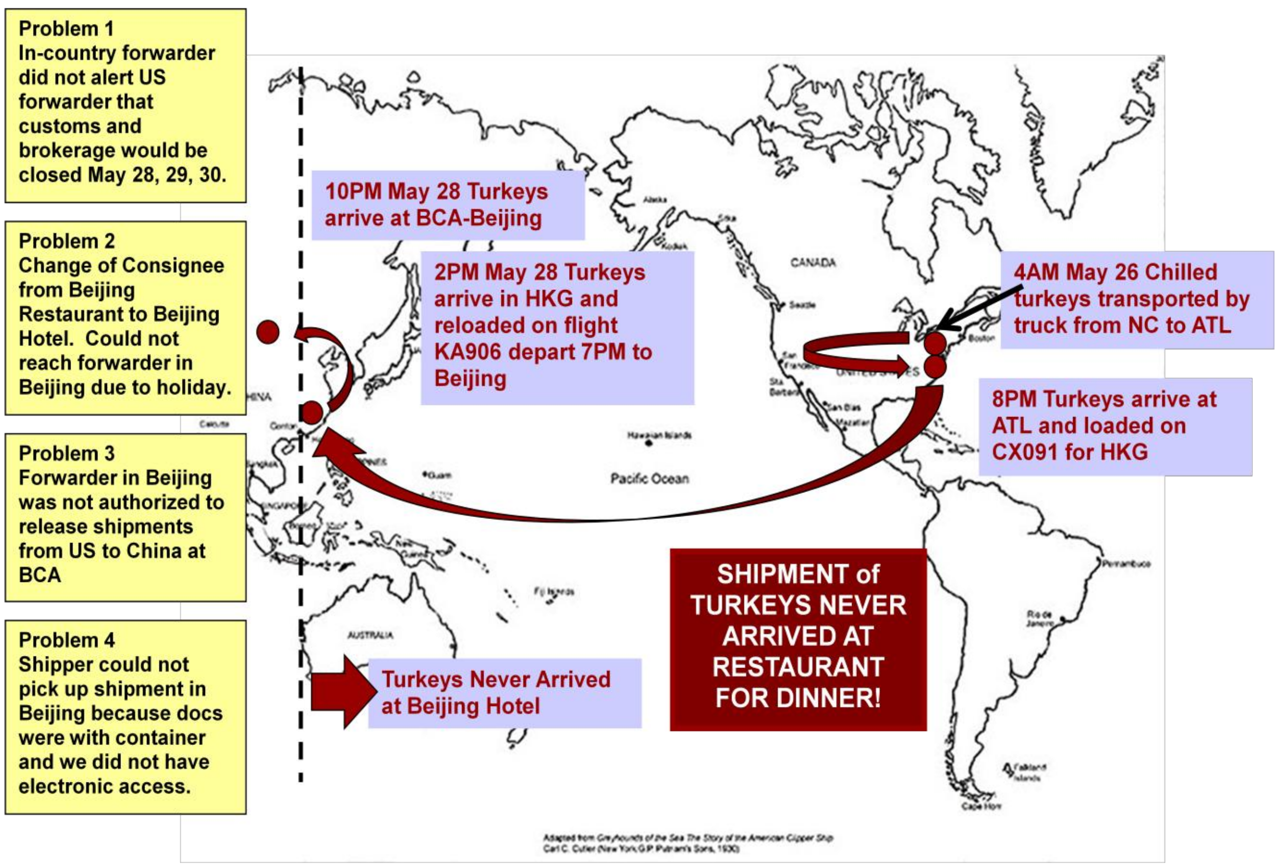
Control Failures. The first failure was one typical of many cold chains—a failure to control the cold chain temperature during the transition between transport modes such as at an airport when the container is moved from one plane to another, or from truck to plane. As is commonly done, dry ice was placed in the container at the processing plant to cool the turkeys. The dry ice caused the container temperature to continue to fall during shipment by truck from North Carolina to the Atlanta airport. However, after arriving in Atlanta, the shipment was removed from the refrigerated reefer and sat in ambient outdoor temperatures while waiting to be placed in the aircraft hold. This resulted in a small rise in temperature. While in the air en route from Atlanta to Hong Kong, the temperature continued to rise in the unrefrigerated cargo hold of the aircraft.

Administrative Failures. Simple administrative failures, such as not following shipment directions, can contribute to cold chain failure. After arriving in Hong Kong, and while waiting to be placed on the continuing flight, we saw above that the container temperature rose. The rapid rise in temperature was due to the fact that the dry ice had evaporated and not been replaced in the container as previously specified in the shipment instructions. After the flight left Hong Kong for Beijing, the temperature remained relatively stable. However, once in Beijing, the temperature rise was due to the fact that the container was kept in an unrefrigerated customs warehouse waiting for clearance. Upon request, dry ice was finally replaced in the container.

Regulatory Failures. Unexpected regulatory barriers are another source of cold chain failure. In this case, a series of regulatory snafus made it impossible to remove the shipment from customs where it was stored in an unrefrigerated warehouse—and also impossible to communicate a change in consignee. First, the freight forwarder in the U.S. did not know that customs offices in China would be closed for three days because of a national holiday.   Thus, the shipment languished in the unrefrigerated warehouse unable to be claimed. Second, because of the customs closure, it was impossible to communicate a change in shipment destination from the restaurant to a nearby hotel which had more refrigeration capacity to keep the turkeys well chilled. Third, the freight forwarder that had been secured by the U.S. freight forwarder did not have the appropriate license to release the shipment from Beijing customs. And, fourth, the in Beijing could not pick up the shipment because the paper documents had been misplaced in transit.

The combination of these problems resulted in a complete failure of the cold chain. In the end, the turkeys remained unclaimed in the warehouse where they thawed completely. Unfit for human consumption, arrangements had to be made for their disposal.

Figure 2: Failures of the Frozen Turkey Cold Chain



EXERCISE: BUILDING A COLD CHAIN FOR ARGENTINE BEEF

In order to minimize the risks of a cold chain failure, it is important to anticipate potential problems such as those revealed by the benchmarking study. In the exercise below, you have the opportunity to plan a cold chain for Argentine beef to minimize potential vulnerabilities.

Argentine beef is extremely popular, both in the U.S. and Europe, due to its natural and unique taste. This taste is attributed to the fact that the cattle are fed with highly nutritious natural grass and in the open range where it develops free of additives and contaminants. This grass-fed beef has been the centerpiece of Argentina's most famous dish, a slow-cooked *asado* on the *parilla.* Beef can be exported chilled or frozen to the U.S. and Europe. Upscale restaurants prefer chilled beef, which require a carefully controlled cold chain.

Think about suitable cold chain routes and schedules for a shipment of chilled AND frozen Argentine beef, respectively, moving from the rendering plant in the pampas of Argentina to a Brazilian restaurant in Chicago. In planning such a cold chain, things to consider include:

- **Pre-Shipment Conditioning**. Products should be conditioned to the desired temperature before being loaded. Cold chain refrigeration technologies are designed to keep a constant temperature in transit, but not to bring a shipment to the shipment temperature. Other concerns include the weather conditions for the destination location, especially if the shipment will be exposed to extreme cold or sun/heat en route.
- **Choice of Mode**. The choice of mode (air, surface, ocean, etc) will have a big impact on the management of the cold chain. Travel time between the origin and the final destination (and any intermediary locations), the size and weight of the shipment, and the required temperature environment all effect the choice of transport mode.
- **Regulatory procedures**. If the freight crosses international boundaries, customs and other procedures must be considered since cold chain products tend to be time sensitive and are more subject to inspection than regular freight (e.g. food, pharmaceuticals, etc.). Depending on the country, the customs times may vary due to variations in regulatory procedures and resulting delays.
- **The Final Leg.** The final leg in the shipment of a product direct to the customer is often known as the “last mile.” Typically local trucking companies manage the last leg and these companies often do not have adequate refrigeration capability, especially in emerging market countries. Shipments are often very vulnerable during the “last mile” and, as a result, efforts and expenses to control and monitor the cold chain upstream can be wasted.

For the above case of Argentine beef:

1. Diagram and specify a cold chain for both chilled and frozen beef products moving from Argentina to Europe and the U.S., respectively. Specify the best modes of transport and the estimated transit times, and consider any special packaging or handling requirements. Discuss the differences for each cold chain.
2. Create possible temperature profiles for the beef in transit across the modes, noting potential vulnerabilities and their impact on the temperature profile;
3. For each cold chain, identify and discuss the risk points and vulnerabilities along the way; and
4. Discuss how you would minimize the risks of temperature deviations that would impact the health and quality of the product.