

ISyE 4803 Advanced Supply Chain Logistics

Fall 2009

Reading Assignment 11

Due Date: November 19, 2009

Readings:

1. Wein, L.M., Wilkins, A.H., Baveja, M. and Flynn, S.E., “Preventing the Importation of Illicit Nuclear Materials in Shipping Containers”, *Risk Analysis*, volume 26, number 5, pp. 1–17, 2006.
2. Lewis, B.M., Erera, A.L., and White, C.C., “Supply Chain Inventory Impacts of Transportation Security Measures and Disruptions”, technical report, *The Logistics Institute*, Georgia Institute of Technology, 2005.

In this study, we will focus on security challenges facing supply chains that rely on international intermodal containerized shipping. Today, the United States’ economy is increasingly reliant on imported goods (both work-in-progress and finished goods). In 2002, the U.S. gross domestic product excluding trade was approximately \$8 trillion, while trade in goods and services totaled \$2.5 trillion. Most experts believe that the value of trade will continue to grow rapidly.

Overland trade (by rail and truck) with Canada and Mexico currently accounts for about \$1 trillion in U.S. trade value. A substantial fraction of the remaining trade is conducted via standardized intermodal ocean container through major U.S. container ports. Each year, approximately 15 million TEUs (twenty-foot equivalent units) of containerized cargo arrive in the U.S.

One major downside of this trade activity is that it appears to be highly vulnerable to exploitation by international terrorists. Indeed, many experts have identified the international intermodal container shipping system as perhaps the system most likely to be exploited by terrorists, and the biggest worry is that the system will be used to smuggle a nuclear device into the country to be detonated either at a port or in a major population center.

Securing this system is a major challenge. Currently, the system has been designed for speed and reliability. Many of the major shippers who utilize the system depend strongly on these features. Unfortunately, measures to secure the system—to make it less vulnerable to exploitation by terrorists—threaten to either slow the system down, or make it less reliable. The broader economic impact of such changes are not clear, but are certainly worrisome for the efficiency of the U.S. economy.

In this case study, we will focus on ideas for securing the intermodal containerized shipping system. We will consider both methods for providing high levels of security with minimal impacts on efficiency, and on simple analysis that attempts to estimate the potential efficiency impacts of poorly designed security systems.

Questions

1. In the Wein et al. article, the authors focus on the design of a testing strategy that will allow government inspectors to detect nuclear devices that terrorists are attempting to smuggle in containers. To optimize the design of such a testing strategy, the authors propose the use of *game theory*. Explain why.
2. Under the game theoretic approach, the U.S. government will deploy a testing strategy and then the terrorists will choose a smuggling strategy. The authors propose therefore to select a testing strategy that *maximizes the minimum probability* of detecting a weapon, where the minimum is taken over all possible terrorist smuggling strategies. This may be a conservative idea. Under what important assumptions will this approach be most appropriate? Why or why not does this approach make sense in this context? (Hint: think about the likelihood that the terrorists will select the *best* smuggling strategy.)
3. Provide a brief description of the U.S. Customs-Trade Partnership Against Terrorism (C-TPAT) program. You may wish to refer to the U.S. Customs and Border Protection website.
4. Provide a brief description of the U.S. Container Security Initiative (CSI). Again, you may wish to refer to the U.S. Customs and Border Protection (CBP) website.
5. Briefly explain the components of the 11 layers of security for intermodal ocean containers.
6. Briefly explain the strategies terrorists might use to disguise a nuclear weapon shipped in an intermodal container. Be sure to consider how a weapon is “concealed” from gamma ray detection devices, neutron detection devices, and active radiography devices.
7. The U.S. Customs service uses a targeting system known as ATS to trigger an alarm if container manifest data indicates anything suspicious about the container. What do the authors assume regarding the probability that the ATS system properly targets a container (and thus deems it *untrusted*) that actually does contain a nuclear device?
8. Section 6 and Appendix B in the Wein et al. paper attempt to model the time required for various inspection strategies at both the port of embarkation (foreign port) and the port of debarkation (U.S. port). Using queuing analysis, the authors generate expressions for T_E and T_D , random variables that respectively represent the time a container spends in active and manual testing at the embarkation and debarkation ports respectively. Describe how these random variables are used in the testing strategy design optimization problem in Section 8.
9. Now let’s look at some results in Figure 4. In the Figure, strategy *DA* representing active testing at the port of debarkation of all untrusted containers, of trusted containers failing passive radiation monitoring, and of some fraction of trusted containers passing passive monitoring appears to outperform other strategies regardless of the

terrorist decision. To achieve a 70% detection likelihood, what is the testing cost per year given each terrorist strategy? Why is it more effective to monitor at the port of debarkation, from the perspective of false positives?

Is it necessarily better from the perspective of a true positive?

10. Explain the concept of electronic container seals. Why are they a promising alternative to testing strategies?
11. Summarize the primary conclusions of the Wein et al. paper.
12. What are the primary strengths of the approach proposed in the Wein et al. paper for increasing the security of the intermodal container shipping system?
Do you believe the authors have appropriately justified most of their important assumptions?
13. In the Lewis et al. paper, the authors focus not on the direct costs of the testing strategy, but rather on the *supply chain cost impact* of testing strategies. Importantly, if containers are delayed due to inspection at ports of embarkation, they may miss their outbound sailing; the container ship is unlikely to wait. Explain how parameters ρ (the probability a container is selected for a manual search) and γ (the probability a container, once selected, will be delayed for M additional periods) are used by the authors to model an *uncertain lead time* for shipment arrivals.
14. Summarize the main results of the section “OPERATING UNDER HEIGHTENED SECURITY”. From a supply chain inventory cost perspective, is it more costly to inspect containers at foreign ports or at domestic ports? Explain the primary source of additional cost.
15. Consider the following scenario: a manufacturer is importing parts for an assembly plant, and the value of one container-load of inventory is \$120,000. Suppose the inventory holding cost per year is 25%; therefore, the cost of holding a container’s worth of inventory for a year is \$30,000. Further, suppose the assembler needs 600 container-loads per year on average ($\mu = 50$ containers per month), and this demand fluctuates randomly with small variance ($\sigma^2 = 120$ containers² per year). Suppose items are sent from Hong Kong to Los Angeles by ship, with a transit time of 14 days, but sailings occur once every 7 days. Further, suppose ordered containers arrive at Hong Kong for embarkation on the day of the order. To ensure that production is interrupted no more frequently than for 1% of the orders, suppose that $\alpha = 0.99$.
 - (a) Suppose this company’s containers were never inspected, $\rho = 0$. Calculate the required safety stock of container-loads, SS . How much does it cost to carry this safety stock each year?
 - (b) Now suppose that this company’s containers are inspected in Hong Kong with low probability, $\rho = 0.02$. However, when inspected suppose that a container misses its sailing with high probability $1 - \gamma = 0.75$. Calculate required safety stock in this case, and its yearly cost.

- (c) A company might be willing to invest some funds to help pay for fast security inspections. Note that if $\gamma = 1$, inspections do not lead to an increase in inventory costs over the case with no inspections. Based on your answers to the first two parts, what would be the maximum charge this company would accept per container to increase γ from 0.25 to 1?

(Hint: Be sure to always use common time units (years or days, for example) for this type of analysis)