Inbound Freight Consolidation for US Manufacturers at China

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Submitted to the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degree of

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Abstract

In recent years, China has become the world factory for a sizable portion of products. Most manufacturing conglomerates in the United States now have contract manufacturing plants in China.

Because many of these US companies have implemented a variety of inventory reduction approaches, they are now faced with the expensive transportation of large numbers of low-weight, small-quantity shipments in international inbound transportation, transportation that covers the flows of goods from contract manufacturers (CMs) in China to original equipment manufacturers (OEMs) in the States. While there has been research on consolidation, little attention has been paid to international inbound freight consolidation, which provides a potential savings opportunity in international transportation by combining several small shipments into one large shipment. This paper examines how manufacturers in the United States can use freight consolidation in their international inbound transportation flow from CMs in China. It then explores a framework for designing inbound consolidation, focusing on how to implement inbound consolidation in the context of China’s fast-evolving logistics industry.

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Introduction

Over the past few years, as one of the most competitive manufacturing platforms in the world, China has attracted a large number of original equipment manufacturers (OEMs) from the United States. Many of these companies have adopted supply chain improvement techniques, such as Just-in-Time (JIT), Lean manufacturing and other inventory reduction practices. These approaches require China’s contract manufacturers (CM) to move small shipments on a more frequent basis. Many OEMs are now faced with the transportation of large numbers of low-weight, small-quantity shipments from China to the United States. In moving these small shipments, companies often encounter rising freight costs and deteriorating services. Therefore, inbound freight consolidation can offer a huge savings opportunity.

International inbound freight consolidation, the operation of combining several small shipments produced at different locations and different times into one large shipment, is a logistics strategy used to deal with the problem of international inbound transportation. Unlike outbound transportation that involves the distribution of goods from OEMs to customers, inbound transportation covers the goods flow from overseas CMs to OEMs. The savings opportunities in inbound consolidation result from the economies of scale that result in lower transportation costs. On the other hand, because inbound consolidation tries to balance cost savings with customer service levels, it can lead to an increase in the length and variability of transit time. The challenge is to design an inbound consolidation strategy that capitalizes on its advantages without downgrading customer service levels.
When devising such a strategy, companies should bear in mind the fast-evolving logistics industry in China. Transportation service quality and availability in China are two main areas that impact the success of inbound freight consolidation. Moreover, inbound consolidation from China is further complicated by such factors as deregulation in the logistics industry, bonded logistics areas, free trade zones, and geographical concentration of suppliers.

Many papers have already addressed freight consolidation. However, fewer researchers have examined international inbound freight consolidation. Moreover, little attention has been paid to how to implement inbound freight consolidation in the context of China’s fast-growing logistics industry.

This paper will first study the reasons for introducing inbound freight consolidation and the methods for doing so. Then it will explore how to implement inbound consolidation in the context of China’s fast-evolving logistics industry. Thirdly, it will use a consolidation framework to explain what determinants should be considered to maximize the costing savings while maintaining high levels of customer service. This part will focus on challenges faced by US manufacturers in inbound consolidation in the areas of transportation infrastructure and transportation service in China. Lastly, the paper will use this framework to analyze the consolidation opportunity in the international transportation of TYCO, a $40 B US manufacturing conglomerate.
2 Literature review in inbound consolidation

Operation activities in supply chain systems are traditionally divided into four functional groups: inbound logistics, processing activities, outbound activities and support activities (Novack, Langley and Rinehart, 1995). With manufacturing outsourcing and off-shoring becoming a strategic option, most US original equipment manufacturers (OEM) are moving towards longer supply chains. Inbound transportation has become a more important structural factor of the supply chain network, directly impacting not only order-to delivery lead-time but also the performance of the whole supply chain network. According to a JPMorgan survey of more than 100 international and domestic shippers (Hoffman, 2005), the respondents expect international transportation is expected to climb from 24 percent of a shipper’s budgets today to 28 percent by the end of the decade.

At present, US OEMs deal with large numbers of relatively low-weight, small quantity shipments in their inbound transportation. In moving these small shipments, companies encounter expensive freight rates as well as slow and unreliable transportation times. As a result, international inbound consolidation, which is the process of combining different items produced at different time into one large shipment, has emerged as a logistics strategy to reduce the costs associated with small shipments.
2.1 Consolidation Methods

Consolidation occurs whenever different items are shipped in the same load. Hall (1987) classifies freight consolidation into three methods: spatial, product and temporal.

Spatial consolidation combines products from multiple locations into a single delivery to a common destination. For example, in inbound consolidation, small shipments from multiple plants can be collected in a small area, consolidated into a large shipment at a consolidation point, and then dispatched.

Temporal consolidation aggregates shipments over time. For example, two kinds of temporal consolidation often used are time-based and quantity-based consolidation. Under the time-based consolidation, a shipment is dispatched periodically with the assurance that product will be shipped within a predetermined time frame when there is sufficient on-hand stock. Under quantity-based consolidation, a shipment is dispatched according to a predetermined threshold quantity. Dispatching time therefore varies from one shipment to another.

Product consolidation concerns grouping different product and/or different transport classification categories from the same origin into a single shipment. Under product consolidation, shipments of different items from a single supplier or multiple suppliers are sorted, consolidated, and dispatched to the customer. Thus, with different orders consolidated at origin, the shipment can be directly delivered to customer. For example, cross-docking can be regarded as one type of product consolidation. Cross-docking is a continuous operation to minimize inventory cost and improve customer service by receiving goods and quickly dispatching them after assortment and consolidation. (Svensson, 2000).
2.2 Basic Consolidation Forms

Manufacturers can use any combination of above the consolidation methods to decide the best consolidation form for their products and selected suppliers. In practice, there are basically three forms of consolidation as follows: inventory consolidation, vehicle consolidation and terminal consolidation (Hall, 1987). As shown in Figure 2-1, Inventory consolidation uses the temporal method; vehicle consolidation uses the spatial method; and terminal consolidation uses both the temporal and product method.

Figure 2-1: Consolidation methods V.S. consolidation forms

Source: Hall. (1987)
(A) Inventory Consolidation

Inventory consolidation is the simplest form of consolidation. As illustrated in figure 2-2, inventory consolidation involves accumulating items that are produced at different times, and transporting them in the same shipment. This is a "temporal" form of consolidation. In practice, inventory is achieved by holding shipments until a cut-off quantity is reached, or by shipping all items in storage according to predetermined time. Inventory consolidation involves storing items before they are delivered. The fundamental decision to be made in inventory consolidation is how to balance transportation costs and inventory holding costs without sacrificing service quality.

Figure 2-2: Inventory Consolidation

Source: Hall. (1987)

(B) Vehicle Consolidation

Vehicle consolidation involves loading and unloading items at different origin and destinations. As illustrated in Figure 2-3, the "milk-run pick-up" is an example in which manufacturers use multiple pick-ups to collect and consolidate parts from their suppliers into a single load. Vehicle consolidation is a "spatial" form of consolidation. The costs under vehicle consolidation are nearly the same whether the vehicle is full or not. Therefore, the more items put on the vehicle, the lower transportation costs per items. The fundamental decisions to make
in vehicle consolidation are the number of stops per route and the time between two routes. If either the number of stops or the time between two routes is increased, more items will be available to load on the vehicle. However, this will deteriorate customer service levels because increasing the number of stop means the route will be longer and increasing time between two routes means that items have to wait longer.

Figure 2-3: Vehicle consolidation

![Vehicle consolidation diagram]


(C) Terminal Consolidation

Terminal consolidation, illustrated in figure 2-4, takes items from different origins to a consolidation point where the items are sorted, and dispatched to different destination according to different shipment release policies. Terminal consolidation is based on both temporal and product method. Terminal consolidation can significantly reduce the number of routes in transportation system. For example, direct transportation from 10 origins to 10 destinations requires 100 vehicle routes, a terminal consolidation can delivery the same number of shipments in 20 routes.
2.3 Determinants of Inbound Consolidation

A number of exogenous factors can affect the performance of inbound freight consolidation. Major factors are listed below.

(1) Total Demand

The number of shipments is important because the greater the number, the greater the likelihood that a consolidated shipment can be formed of items with similar characteristics. Moreover, larger numbers of small shipments can be grouped into relatively larger shipments, thus achieving discounts on transport. When demands are distributed more uniformly, the opportunities and benefits of consolidation will further increase.
(2) Cost value of shipments

The impacts of the price level of items on the advantages of freight consolidation need to be examined. On the one hand, when the costs levels are high, traditional inventory replenishment policy is typically associated with smaller order quantities, thus increasing opportunities for consolidation. On the other hand, more costly items are better able to absorb high freight charges, thereby diminishing the advantages of freight consolidation.

(3) Freight Spread

The pressure for large shipments comes from high unit freight costs for small shipments. The freight cost spread between consolidated shipments and small shipments determines the saving opportunity from shipment consolidation. It is obvious that the growing of freight spread increases economic attractiveness of freight consolidation. For example, one airfreight structure from UPS is designed as follows for the shipment from Shanghai to Houston, TX: If shipment weighs above 1000 kilograms, the airfreight is $3.25 per kilogram; For shipment below 100 kilograms, the airfreight is $4 per kilogram. The freight spread is now $0.75 per kilogram. It is clear that the larger freight spread, the more savings opportunities for consolidating small 100-kilogram shipments into an above-1000-kilogram shipment.

(4) Quantity discount

The potential benefits from inbound consolidation are offset by the attractiveness of purchasing quantity discount that are controlled by the discount percentage and quantity breakpoint. High discount leads to larger order quantity. Shipment size tends to be large, and opportunities to consolidate these large shipments decrease. Thus it can be assumed that the
relative benefit of freight consolidation is diminished when attractiveness of quantity discount is high.

2.4 Impacts of Inbound consolidation

While it is clear that inbound freight consolidation can reduce transportation costs, other effects on the whole supply chain may not be obvious. Some possible effects or results might be:

(1) Inventory Costs

Inbound freight consolidation requires holding inventory at its consolidation points until the desired shipping quantity for the destination is available. This can result in a higher average level of inventory for the firm as a whole. It can be assumed that freight consolidation leads to higher overall inventory cost. But the increased inventory costs cannot be determined without specific information regarding demand, transit time, distribution system and relevant product information.

(2) Customer Service Level

In inbound consolidation, the customer service level may suffer because of increases in the length of delivery time because the company would hold small shipments for consolidation. On the other hand, consolidation is achieved by accumulating small shipments at consolidation points over a period of time; this may avoid the fact that small shipments have uncertainties in arrival time and shipment size at the destination.

(3) Vulnerability of supply chain system
Inbound consolidation adds operational efficiency by coordinating operations among suppliers, services providers and manufacturers. The more efficient and integrated a supply chain network becomes, the more likely uncertainties, dynamics and accidents in one part will affect the other parts in the network. (Aksel, Heide and Wathne, 2003). The overall system performance is influenced by activity from every party in the supply chain flow. Therefore inbound transportation increases potential vulnerability in the system by one party’s overdependence on others parties.

4) Partnership with the logistics service providers.

Inbound freight consolidation arrangement can influence the nature of the relationship between the logistics service providers and manufacturers. According to the research of Lambert, Emmelhainz and Gardner (1996), there are three different types of partnerships, identified as Type 1, Type 2 and Type 3 (figure 2-5)

![Figure 2-5: Types of supply chain relationships](image)


Compared with type 1 partnerships that have a short-term focus and involve only a few areas within each organization, type 2 partnerships have a long-term focus by integrating activities of each party. Inbound freight consolidation arrangements reflect a long-term focus and increased level of involvement between the parties, because of more information sharing, operation
integration and committed resources from each party. Inbound freight consolidation reflects higher-level partnerships than those under traditional ocean or airfreight contracts. The partnerships between service providers and manufacturers will move from Type 1 to Type 2 in the hierarchy of supply chain relationship.

5) Administrative expense.

Extra administrative efforts and facilities are required to plan, operate, and maintain freight consolidation. The time and money can be considerable when compared to direct moving small shipments.

2.5 Closure

This chapter was to provide a review on inbound consolidation and to explain the freight consolidation methods, the basic consolidation forms, the determinants of inbound consolidation, and the impacts of consolidation on the supply chain system.

We first discussed three freight consolidation methods: spatial, product and temporal. They are the basic and key ingredients for an inbound consolidation strategy. When devising international inbound consolidation, companies can use any combination of these consolidation methods to choose an appropriate consolidation form according to the management objective and business constraints. Three basic consolidation forms in practice are inventory consolidation, vehicle consolidation and terminal consolidation. Each of them is derived from above mentioned consolidation methods. For example, inventory consolidation is mainly based on the temporal method; vehicle consolidation is on the spatial method; and terminal consolidation is on the combination of the three consolidation methods.
When a consolidation form is evaluated for international transportation, a number of exogenous factors, such as product demand, cost value of shipment, freight cost spread, and possible quantity discount, should also be considered. These factors can affect the performance of inbound consolidation strategy in terms of costs saving opportunities. However, inbound transportation is the part of a company’s whole supply chain system. Except for the cost savings in transportation, the impacts of transportation consolidation strategy should also be evaluated in the context of the whole supply chain network, such as inventory costs, customer service level, vulnerability of supply chain system, partnership with logistics service providers, and administration costs.

In the global supply chain dynamics, there exist more uncertainties in those determinants of inbound consolidation and in the impacts of inbound consolidation on the whole supply chain system. Therefore, an international inbound consolidation should be carefully evaluated in these areas before the correct consolidation form is selected to maximize the benefits from international inbound consolidation. This is especially true in designing the inbound consolidation from China, where the development of logistics is rapid. This is discussed in the next chapter.
Constraints and Developments of China’s Logistics Industry

Inbound freight consolidation can bring substantial benefits to companies, but it also comes with risks and uncertainty in their global supply chain. "Transporting goods over a long distance often means switching logistics providers, and integration is not always seamless. The result is a lot of paperwork. Also, different regions have different regulations; these non-tariff trade barriers all add to logistics costs," says Udo Jung, a vice president with Boston Consulting Group. "Bringing products from China into the United States can be like walking through a minefield. Any misstep can be costly, especially when companies adopt inbound freight consolidation." (Smith 2000)

This chapter will address the constraints and development of the current China Logistics Industry. This will be instrumental in designing and managing the inbound consolidation between China and the United States.
3.1 Transportation service quality and availability

Transportation service quality and availability are two main areas that have an impact on the success of inbound freight consolidation strategy. In an annual survey of chief executive officers from third-party logistics providers operating in the Asian Pacific region, Lieb and Bentz (2006) asked CEOs to comment on their companies’ experiences on these two issues for each mode. These target companies included Caterpillar Logistics Services, DHL, Eagle Global Logistics, Exel Logistics, Geologistics, Meridian IQ, Ryder, TNT and UPS Supply Chain Solutions. Their responses are summarized in the following table 3-1:

Table 3-1: CEO rankings of transportation availability and transportation service in China 2005

<table>
<thead>
<tr>
<th>Mode Service</th>
<th>Excellent</th>
<th>Very good</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Intercity rail</td>
<td>---</td>
<td>---</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2.6</td>
</tr>
<tr>
<td>2.Truckload</td>
<td>---</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>---</td>
<td>3.4</td>
</tr>
<tr>
<td>3.Less-than-truckload</td>
<td>---</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>3.6</td>
</tr>
<tr>
<td>4.Local cartage trucking</td>
<td>---</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>3.6</td>
</tr>
<tr>
<td>5.Parcel delivery</td>
<td>---</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>---</td>
<td>3.2</td>
</tr>
<tr>
<td>6.Domestic water carriage</td>
<td>---</td>
<td>---</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>7.International ocean carriage</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>---</td>
<td>4.8</td>
</tr>
<tr>
<td>8.International air cargo service</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>---</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Sources: 3PL users survey, Robert Lieb, Brooks A, Bentz
Remark: Average Score is based on five-point scale. Excellent: 5, Very good: 4, Good: 3, Fair: 2 and Poor: 1.

Source: Lieb and Bentz (2006)
According to the average scores from their responses shown in Figure 3-1, it is obvious that international transportation has a higher level of satisfaction in service quality and availability than local transportation does. International ocean carriage and international air cargo service are satisfactory to the companies in the survey. Intercity rail, parcel delivery, and trucking service need an improvement in both transportation availability and service quality. Domestic water carriage is viewed as the worst service mode, especially in the service quality. Therefore, managers should choose the efficient and cost-effective service mode to meet the transportation requirements from inbound consolidation, and take into account the difference between international and local transportation in designing the end-to-end transportation solutions. Moreover, companies should bear in mind that each local transportation mode has its own
distinctive advantage. For example, in certain situation, inland water transport is a very cost-effective service mode for non-time-sensitive products over long distance.

What’s more important, as shown in figure 3-1, transportation service quality and transportation availability are highly correlated. The correlation efficient is about 0.94. It can be expected that transportation service quality will be improved rapidly in the next decade, because of the improvement in transportation availability from government’s huge investment in the transport infrastructure. As a result, when devising the inbound consolidation strategy, US OEMs need to pay close attention to the rapid development of China transport infrastructure and the transport service.

3.1.1 Transportation Infrastructure

China’s rapid development and burgeoning trade is placing increased pressure on the country’s logistics systems. Because the country lacks adequate road, rail, air and port infrastructure, companies entering the Chinese market have been unable to apply standard approaches to supply chain management. The government of China has made substantial investment in upgrading the transportation infrastructure over the past decade. However, transportation infrastructure remains a bottleneck. Chinese government has made the commitment to modernize and expand its transportation infrastructure. In the guidelines of the five-year development blueprint, some key transport infrastructure projects are set to build during the 2006-2010 period (“China’s Key Transport Infrastructure Projects for 2006-2010” 2006):
- Railway: six railways, including one between Beijing and Shanghai, five inter-city railways, including one between Beijing and Tianjin, and the upgrading of five existing railways including one between Datong and Qinhuandao.

- Highway: 14 expressways including one from Beijing to Hong Kong and Macao.

- Ports: Transit system for the transportation of coal and import oil, gas and iron ore, and containers transport systems at 12 seaports, including those in Dalian, Tianjin and Shanghai.

- Shipping: the third-phase project for dredging the deepwater channel at the mouth of the Yangtze River, the course at the mouth of the Pearl River to the sera, Channel dredging in the Yangtze and Pearl River valleys and the Beijing-Hangzhou Canal; and acceleration of port construction along inland rivers.

- Airports: expansion of ten airports including those in Beijing, Shanghai and Guangzhou relocation of the two airport in Kunming and Hefei; and airports in central, western and northeastern China to accommodate flights on feeder lines.

**Roads:**

Compared with the nation’s vast land size, dense population, and fast growing transport demands, the total expressway mileage in China, given the existing 30,000 KM expressway, is insufficient. The government has begun to construct a national trunk highway system (Figure 3-1) that links major production and consumption sites.
This National Expressway Network Plan (NENP) includes 7 radiating lines from Beijing, 9 lines from north to south and 18 from east to west ("The national expressway network plan", 2006). The total costs of the national expressway network will be 2 trillions RMB plan (about 240 billion US dollars). Upon its completion, the national expressway will serve to:

- Cover a population of over 1 billion; the GDP of covered regions should amount for 85 percentage of the national GDP.

- Link all the provincial capitals, among them 83% percent of 500,000 populated big cities and 74 percent of 200,000 populated medium sized cities.
• Link all the important transportation hub cities, included are 50 railway hubs, 67 airway hubs, 140 overland hubs and 50 waterway hubs, forming a grand integrated communications network

• Strengthen the communication between the economically developed areas. At the same time, the role of such big hubs as Beijing, Shanghai, Guangzhou will be further strengthened

• Link main national first grade border highways to strengthen the external communications.

**Railways**

At 75,000 kilometers, China’s railway system is the third largest in the world, coming behind only America (230,000 km) and Russia (85,000 km). Rail is a focus of China’s current development strategy, aiming to make the railway network comprehensive and nationwide.

The government has started large-scale railway construction with the objective of developing a comprehensive network over the next five years. According to a People’s Daily report on January 8 2006, it is announced that China will construct new railway lines stretching 17,000 kilometers. This plan will be carried out over the next five years (2006-2010) to develop a comprehensive railway and rapid transit system network. The plan will involve a total investment of 1,250 billion RMB (about US$155 billion).
The freight transportation network will be enhanced. Four existing north-south lines will be converted to an electric system, including lines from Beijing to Shanghai, Beijing to Guangzhou, Beijing to Kowloon, and Jiaozuo to Liuzhou. Total freight capacity will reach 400 million tons or more. The line linking Tianjin, Qinhuangdao and Shenyang will also be electrified to raise its freight transportation capacity to 120 million tons. An east-west passage will include routes from Shanghai to Wuhan to Chengdu, and from Lanzhou to Chongqing, Xi'an to Ankang and Kunming to Liupanshui, with freight capacity in and out of the southwestern region of the country of up to 300 million tons. Routes in and out of the northwestern region will include the construction of double-track railways from Taiyuan to Zhongwei to Yinchuan, from Lanzhou to Chongqing and Lanzhou to Wuwei, and electrification of the railway from Shizuishan to Lanzhou to enhance freight transportation capacity to over 200 million tons. These measures should solve current issues relating to national economic development being hampered by a lagging railway system.

**Seaport**

By the end of 2003, there were over 3300 productive berths in coastal ports of the country, the total handling capacity of which was nearly 1.7 billion tons, and among which there are 745 deep-water berths with the capacity of over ten thousand tons each. Extreme growth was also followed by high demand in logistics and transportation. China ports saw a constant growth at a very high level, as illustrated in Table 3-2. In 2004, the top Chinese mainland container ports grew by more than 25 per cent compared with traffic results for 2003.
Table 3-2: Container traffic: the ten fastest growing ports in 2004.

<table>
<thead>
<tr>
<th>Port</th>
<th>Country</th>
<th>Total TEU (in 1000) 2003</th>
<th>Total TEU (in 1000) 2004</th>
<th>% Change over prev. year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ningbo</td>
<td>China</td>
<td>2750</td>
<td>4006</td>
<td>45.7</td>
</tr>
<tr>
<td>Jeddah</td>
<td>Saudi Arabia</td>
<td>1787</td>
<td>2426</td>
<td>35.8</td>
</tr>
<tr>
<td>Dalian</td>
<td>China</td>
<td>1670</td>
<td>2212</td>
<td>32.4</td>
</tr>
<tr>
<td>Shanghai</td>
<td>China</td>
<td>11280</td>
<td>14558</td>
<td>29.1</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>China</td>
<td>10650</td>
<td>13655</td>
<td>28.2</td>
</tr>
<tr>
<td>Tianjin</td>
<td>China</td>
<td>3000</td>
<td>3815</td>
<td>27.2</td>
</tr>
<tr>
<td>Khor Fakkan</td>
<td>UAE</td>
<td>1449</td>
<td>1819</td>
<td>25.5</td>
</tr>
<tr>
<td>Dubai Ports</td>
<td>UAE</td>
<td>5152</td>
<td>6429</td>
<td>24.8</td>
</tr>
<tr>
<td>Long Beach</td>
<td>US</td>
<td>4658</td>
<td>5780</td>
<td>24.1</td>
</tr>
<tr>
<td>Qingdao</td>
<td>China</td>
<td>4240</td>
<td>5139</td>
<td>21.2</td>
</tr>
</tbody>
</table>

Source: ISL Port Data Base 2005

Three Chinese ports already rank among the top five seaports worldwide, namely Hong Kong, Shanghai and Shenzhen. Many of China’s container terminals are now up to world standards, dispatching goods with very high efficiency. China has begun to further exploit the Yangtze River to transport more goods, since the Three Gorges dam should now control its seasonal flooding.

At present, in order to better service the need of the growth of economy and foreign trade of the country, China has accelerated the construction of a series of shipping infrastructure projects. The focus has been directed on speeding up the construction of the Yangshan Deep Water Port and the Yangtze River estuary deep-water channel project.

Shanghai’s Yangshan port, the world’s highest-profile container port project, has now started operations on a pair of islands tens of kilometers from the coast, connected to the mainland by a vast bridge. The new deepwater port will be finished in 2020 with over 50 container berths. Each will be quipped to handle fifth and sixth generation container vessels, reaching an annual handling capacity of around 25 million TEU.
Airport

There are about 150 commercial airports in China. The total cargo throughput in 2005 is about 6.3 million tons, a 14.6% increase over 2004. According to General Administration of Civil Aviation of China (CAAC), total number of commercial airport will reach 237 by 2010. (Jiang, Ren, and Hansman, 2003). The major efforts will be made to improve operational capacity at the hub airports.

Beijing Capital is the largest airport in North China. It has recently been united with Tianjin airport. In East China, Shanghai has two large airports, Hongqiao and Pudong, serving domestic and international routes respectively. In the Pearl Delta of South China, there are three mainland airports, Guangzhou, Shenzhen, and Zhuhai. This is in addition to the Hong Kong airport and Macau airport in the same area. The cargo throughputs of large mainland airports centered at Beijing (Beijin, Tianjin), Shanghai (Hongqiao, Pudong), and Guangzhou (Guangzhou, Shenzhen) accounted for 13.6%, 35.0% and 16.8% of mainland total cargo throughput respectively.

A forecast of future air cargo demand in Mainland China and specific forecasts of cargo throughput at some major airports including Hong Kong and Taipei is presented Table3-3. (Jiang, Ren, and Hansman, 2003)
Table 3-3 Extrapolated Projections of cargo throughputs at three airport groups and large airports in Mainland China, Hong Kong and Taipei

Unit:000 tons

<table>
<thead>
<tr>
<th>City/Airport</th>
<th>2002</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shanghai Pudong/Hongqiao</td>
<td>1075</td>
<td>1804</td>
<td>4276</td>
</tr>
<tr>
<td>Guangzhou/Shenzhen</td>
<td>786</td>
<td>1134</td>
<td>2089</td>
</tr>
<tr>
<td>Beijing/Tianjin</td>
<td>671</td>
<td>935</td>
<td>1625</td>
</tr>
<tr>
<td>Shenyang</td>
<td>57</td>
<td>75</td>
<td>118</td>
</tr>
<tr>
<td>Xi'an</td>
<td>65</td>
<td>84</td>
<td>130</td>
</tr>
<tr>
<td>Chengdu</td>
<td>162</td>
<td>219</td>
<td>362</td>
</tr>
<tr>
<td>Kumming</td>
<td>122</td>
<td>195</td>
<td>424</td>
</tr>
<tr>
<td>Wuhan</td>
<td>52</td>
<td>58</td>
<td>70</td>
</tr>
<tr>
<td>Urumqi</td>
<td>43</td>
<td>53</td>
<td>75</td>
</tr>
<tr>
<td>Dalian</td>
<td>73</td>
<td>99</td>
<td>167</td>
</tr>
<tr>
<td>Chongqing</td>
<td>71</td>
<td>91</td>
<td>135</td>
</tr>
<tr>
<td>Qingdao</td>
<td>46</td>
<td>61</td>
<td>97</td>
</tr>
<tr>
<td>Hangzhou</td>
<td>87</td>
<td>129</td>
<td>249</td>
</tr>
<tr>
<td>Nanjing</td>
<td>52</td>
<td>68</td>
<td>107</td>
</tr>
<tr>
<td>Fuzhou</td>
<td>48</td>
<td>60</td>
<td>86</td>
</tr>
<tr>
<td>Xiamen</td>
<td>110</td>
<td>140</td>
<td>211</td>
</tr>
<tr>
<td>Zhuhai</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Haikou</td>
<td>54</td>
<td>63</td>
<td>81</td>
</tr>
<tr>
<td>Lhasa</td>
<td>9</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>2479</td>
<td>3212</td>
<td>4948</td>
</tr>
<tr>
<td>Taipei</td>
<td>1381</td>
<td>1698</td>
<td>2396</td>
</tr>
</tbody>
</table>

Source: Jiang, Ren, and Hansman. (2003)

Summary

The planned investment in upgrading the transportation infrastructure, especially that of roads, rails, seaports and airports will have a huge impact on the inbound consolidation decision:

- With the reliable and convenient transportation network, companies will have more options in selecting the form of inbound consolidation. The consolidation point will be no longer restricted to major cities in coastal areas. Companies will have more choices in consolidation points, such as the second tier cities which have both production capacity and access to domestic transportation network and export terminal, such as Suzhou, Wuxi, Shenyang, Wuhan.
The transit time, which is now plagued by bottlenecks in the existing transportation network such as intermodal capability and congestion, will be reduced and become reliable. Effective transport networks increase reliability in pick up and delivery time and transparency in the shipment process. Thus service level and reliability in inbound consolidation can be increased accordingly. For example, it takes about 20 days to move the product by rail from western city to Shanghai. There’s no intermodal capability, and product is loaded and unloaded by hand. Because of the country’s astonishing size and the magnitude of the infrastructure deficiencies, incremental improvements will be the rule for the foreseeable future. However, it can be expected that the transit time from most western cities to coastal cities will be reduced to less than one week over the next 10 years.

The growing transportation infrastructure will offer more freedom in choosing the transport modes. Currently, China’s most common transport mode is road, however, rail, air and waterway will be more attractive with the upgrade in the infrastructure. These new mode choices will increase the coverage of inbound consolidation to different products and supplier that have different requirements on transit-time, cost and service levels. For example, HAVI food services, which distribute for McDonald’s, uses refrigerated truck fleets for China distribution, even though rail would be ideal if a reliable cold chain services were available at a competitive price (Easton 2006).

Companies should bear in mind that China’s rapid growing infrastructure will change the optimization of inbound consolidation network. Managers should review and adjust the system from time to time to maximize the benefits of inbound consolidation. For example, the fast growing transportation infrastructure will reduce the transportation and
warehousing cost by increasing the efficiency of transportation network. This will affect the network design of inbound transportation consolidation, which is usually characterized as a balance between transportation costs and inventory holding costs.

### 3.1.2 Transportation services.

Many companies now complain about a number of frustrations in moving their goods within and across China, such as high logistics costs, loss and damage of goods, a lack of visibility in shipment processes and so on. This section will discuss 1) current transportation services in rail transport, road transport and water transport, which will be helpful to avoid pitfalls in current inbound consolidation and 2) impacts of transportation deregulation.

**Rail Transport**

Although rail remains the cheapest from of overland transport, several shortcomings make the rail system incapable of satisfying sophisticated customers and stringent service requirements (Wu, 2003).

First, incompatibility among ocean shipping and railway limits the development of inter-model rail system. For example, a lack of inter-modal links and rail sidings at ports and plants often make rail options infeasible. Without inter-model link, containers cannot be loaded onto trains from vessels and truck. And without rail sidings, goods must be double handled at both loading and unloading points. Moreover, since trucks must be used to get goods to and from the rail system, and since shipping containers are also loaded on trucks for onward transportation, it often makes more sense to use trucks alone.
Second, the lack of service orientation and handling practices in the rail industry are extremely unsatisfactory. For example, booking can take weeks without the right guanxi, or relationship. Poor handling compromises the quality of the product. More damage occurs to goods transported by rail than those by road. Damage usually occurs during loading and unloading processes. Workers are usually not adequately trained to handling sensitive goods. Damage rates are estimated to be three times than for road transport (Easton, 2006)

Third, China’s rail networks lack automation, thus making the entire system manual and delay-prone. The current rail system has little flexibility in schedule and extensive delay. The delivery time of cargo rail transportation is unreliable because cargo has a low priority in the rail system compared with passenger traffic. Delivery windows generally measured in weeks rather in days. For the time sensitive products, shipping by rail is too slow and unpredictable. For example transit time from Shanghai to a northern province average 15 to 45 days, and up to 60 days to the Northeast region.

**Road Transport**

This mode of transport in China suffers from considerable limitations; however, it promises to be the best mode for land-based logistics solution, because it offers the most flexibility and control over delivery time and the delivered condition of goods. The trucking industry is extremely fragmented in China. No single trucking company is able to provide national coverage. It is estimated that 5.4 million trucks are registered to more than 2 million trucking service providers an average of 2.7 trucks per company (Easton, 2006). Investment in expressways has expedited run time, especially for long haul shipments. Road transport is most
popular transport mode in China. However, the shippers and truck companies continue to experience following problem: (Wu, 2003)

First, local government regulations are inclined to protect local business by limiting entry of trucks carrying goods from other regions. This results in higher operation cost and longer transit time. For example, non-local registered trucks are limited to entering the city area during the day.

Second, trucking prices are rising because of heavy cost burden imposed by toll roads, stringent emission codes, and increasing fuel prices. Higher capital costs present financial barriers for local and small trucking companies to upgrade their equipment and facilities.

Third, truck maintenance is neglected. Although vehicles are required to be inspected on a regular basis, few companies follow the regulation. This means that cargo is vulnerable to damage.

Fourth, overloading of goods, as a way of cost reduction, is rampant. It is quite common that vehicles haul some 50% in excess of their legal payload.

**Water Transport**

Shipping, both coastal and inland, accounts for half of all domestic freight traffic. Domestic water carriage is suited for moving bulk commodities. About two-thirds of local barge traffic is comprised of commodities for agriculture and industry, such as coal and grain. Shipping by barge is cheap, however outdated equipment, inflexible shipping schedules, low delivery reliability, high pilferage and damage rate, inadequate IT systems and obsolete inland infrastructure place domestic water carriage uncompetitive with road.
In general, ocean and inland water transport is not suitable for moving time sensitive freight and finished goods. However, some multinational companies such as Procter & Gamble have found that inland-water can be cost-effective in certain situation. (Easton, 2006). For example, they use inland water transport to backhaul from Beijing to Guangzhou because it is cheaper than road transport and there are no additional costs.

**Air Transport**

Airfreight is under the rapid development and has greater potential, but its use can be problematic today. Three domestics airlines dominate the airfreight market: China Eastern, Air China and China Southern. Airlines routes in China are highly fragmented as shown in figure 3-3, and most airlines focus heavily on the passenger, not cargo. Inefficient information exchange between airlines and freight forwarders can make coordination and delivery a trouble.
In Mainland China, domestic air cargo is primarily carried in the belly space of passenger aircraft. Therefore, the type of passenger and the frequency of flights determine the cargo capacity of a specific route. The demand for domestic air cargo is still at low level.

As for International air cargo transportation, over the past few years, national flagship carriers have been expanding the long-haul freighter fleets to capture the demand. The problems facing mainland airports and carriers are the limited network connections to the world, cargo handling inefficiency and lack of ground accessibility to major international hubs for shippers.
Transportation deregulation

As part of the terms of China’s WTO entry, China agreed to open market sectors and services that had been previously protected from global competition. The opening of the distribution and logistics is expected to spur the development of transportation and logistics services in two ways.

First, WTO entry opened up several transportation and logistics sectors to direct foreign participation. Foreign companies are allowed to own 100 percent of Chinese freight forwarding, third-party logistics and customs brokerage firms, trucking, domestic express and air parcel services. Rail service will be open to 100 percent foreign ownership before 2008. These non-Chinese logistics players serve primarily multinational companies, generally in export- and import-related logistics. They now can extend their service further into China using several transport modes and link these services to their already strong global supply chain networks. For example, Orient Overseas Container Line (OOCL) offers specialized bonded rail links ports to a few selected inland cities. Therefore, these foreign logistics service providers can improve service inbound consolidation by developing workable domestic solutions for their multinational clients.

Second, transportation deregulation paved the way for new, often foreign investors to collaborate with large state owned companies like Sinotrans, COSCO and China Rail, who own most of the hard assets. Recognizing the antiquated state of the sector, the Chinese government has given it priority for development. As a result, asset-heavy incumbent companies are now actively looking for technical and operational know-how. All have initiated plans to transform themselves from purveyors of basic services to providers of value-added solutions. Their existing advantages of huge assets and wide network make them formidable competitors. With the
partnerships and cooperative arrangements with leading foreign third-party logistics companies, these incumbents are moving aggressively to upgrade transportation and logistics service. Thus in designing the inbound consolidation solution, those service concerns on existing transport mode can be mitigated.

3.2 Bonded Logistics Zone

In the 1990's, China has established 15 Free Trade Zones (FTZ) for international trade, foreign investment, bonded warehouses, and export processing. The locations of FTZs are shown in figure 3-4.

Figure 3-4: 15 Free Trade Zones in China

FTZs in china are geographically defined areas ranging in size from smaller than 1 km$^2$ up to 10 km$^2$. They are treated outside of Customs supervision areas and offer preferential policies such as tax incentives, customs duty incentive. All 15 free trade zones have access to ports, but

all these free trade zones are working isolated from nearby seaports. Imports, export and distribution have to undergo customs check procedures of both the port and FTZ. Therefore, the logistics functions of these free trade zones could not come into full play. In order to develop the international logistics industry and to promote China as an international logistics center, China’s government approved a new Shanghai Waigaoqiao Bonded Logistics Park as a first pilot. The layout map is illustrated in figure 3-5. In 2004, seven other bonded logistics parks were established, which are Dalian, Xiamen Xiangyu, Tianjin, Qingdao, Zhangjiagang, Shenzhen, and Ningbo.

Figure 3-5: Layout map of Shanghai Waigaoqiao Bonded Logistics Park

![Layout map of Shanghai Waigaoqiao Bonded Logistics Park](image)

Source: Exel Logistics East China Solution Team

By simplifying export/import procedures and speeding up shipment circulation, these bonded logistics parks are expected to satisfy the needs of multinational companies in China for the transshipment and supply of products in the global market place.

The bonded logistics park are designed to have the following four functions:
(1), International Cargo Intersection

This means that foreign carrier’s cargos, whose destinations are non-Chinese ports, are allowed to be de-consolidated temporarily in China and be shipped to other countries after reconsolidation.

(2), International Distribution Center

This means that inbound goods can be kept in logistics park and distribute upon market demand

(3), International Purchasing Center

That is to promote and enlarge export through Logistics Park; Cargo in Logistics Park is taken as export goods

(4), International Entrepot Function

This means that the companies in the logistics park can operate trading service with transit trade as its core business and speed up the international logistics operation.

Bonded Logistics Park also enjoys the related preferential policy of the Free Trade Zone. Shipment to bonded logistics park is considered as exportation and value add tax (V.A.T) can be refunded immediately. Shipment out of bonded logistics park to domestics market is considered importation and duty/VAT should be levied.

Multinational companies can use bonded logistics park as a regional procurement and distribution center, supply goods to overseas markets, regional market and China markets. It is estimated by Orient Overseas Container Liner (OOCL) that the costs of transportation and
consolidation could be reduced by about 25% for consolidated shipments from the Central China to U.S. if the shipments are consolidated at Waigaoqiao Bonded Logistics Park. What’s more, because of the simplified customs declaration procedure for exporting shipment from these Logistics Bonded Park, the processing time of a shipment from consolidation warehouse to loading on the vessel can be decreased to one or two days, compared with 6-7 days if the shipment is outside the Park. With its advantages in logistics facilities, convenient import and export process and preferable fiscal incentives, the bonded logistics park can be an ideal location choice of consolidation terminal in international inbound consolidation.

3.3 Closure

The objective of this chapter was to provide background on transportation infrastructure development, transportation service and newly established bonded logistics park and to discuss their impacts on inbound consolidation from China contract manufacturers.

The rapidly developing transportation infrastructure will have a huge impact on the designing the inbound consolidation strategy in China. With the upgraded transportation networks, companies can provide more reliable transportation consolidation solutions, have more freedom in selecting transport mode according to the strategy, and have the opportunities to move to consolidation terminal from the east coastal area to hinterland to better serving the fast-growing production facilities in the west regions. Moreover, when designing an inbound consolidation strategy, managers should emphasize both internal transportation and domestic transportation. More important, managers should take into account not only current bottlenecks but also rapid development in transportation infrastructure. Therefore, a successful inbound consolidation strategy should be flexible enough to adapt to future infrastructure development.
Transportation service is another important area. The logistics industry in China is now in the transition period after the country entered the WTO in 2001. On the one hand, because of historical reasons of government protection, there still exist different limitations and frustrations in current transport modes of rail, road, air and water. On the other hand, because of deregulation and global competition, more and more logistics service provider high-quality service. Thus, in designing the inbound consolidation, it is important for managers to avoid pitfalls in different transport service mode and select qualified logistics service providers in China.

In 1990’s, China established 15 free trade zones (FTZs), which have played a very important role in economic development in the east coastal areas. As a further step in logistics from current FTZs, eight bonded logistics parks have been established by the government in 2004 to develop the international logistics service. With the advantages in logistics facility and policies, these parks should also be considered in the design an international transportation consolidation strategy.

A framework, then, is needed to take into account the important considerations from fast-evolving logistics industry in China and inbound consolidation in previous chapter. Next chapter discusses a framework to implement the inbound consolidation strategy from China.
4 A Framework for Designing Inbound Consolidation Strategy

Inbound freight consolidation is a complicated and multifaceted operation. Many companies use combinations of consolidation methods that vary on the product, the customer, the demand, the origin and destination, and so on. International inbound consolidation from China is further complicated by the fast growing logistics development in China. Therefore, the framework for international inbound consolidation are recommended as illustrated in figure 4-1:
Figure 4-1: A framework for inbound consolidation strategy

1. Identify the potential products
2. Select the potential Contract Manufacturer (CM)

- CM with suitable products?
  - Yes: Select service provider
  - No: Reevaluate later

3. Select the consolidation form and consolidation terminal

- Is inbound consolidation profitable?
  - Yes: Evaluate impacts and implementation feasibility
  - No: Reevaluate later

4. Satisfactory results?
  - Yes: Implement
  - No: Reevaluate later
1, Identify potential products

Before starting the international inbound consolidation, the original equipment manufacturer (OEM) should review its current operations and select the products for which inbound consolidation could be the best available delivery model.

Direct shipping is the most cost-effective for products that are ordered and shipped in quantities large enough to form a full or near full container load from a single supplier. Direct shipping is required for goods that are time-critical, because it provides the shortest lead-time from Chinese contract manufactures (CMs) to US original equipment manufacturers (OEMs). Inbound consolidation is a cost-effective solution for products that have long lead-time and are ordered in small quantities.

A company should also consider the total demand and the demand distribution pattern of the product. The number of shipments is important because the more the shipments, the greater the opportunities that a consolidated shipment can be achieved. When demands are distributed more uniformly, the opportunities and benefits of consolidation will increase. Moreover, the physical characteristics of shipments, shipping and package requirements, the freight structure in the shipping contract, and potential quantity discount shall also be evaluated in identifying the potential products for consolidating.

2, Identify the potential contract manufacturers.

Inbound consolidation is a highly coordinated operation. Except for the geographical location and shipping volume, several other requirements should be considered when selecting a CM. First, there should be efficient communication between the CM, the service provider and the
OEM. It is important for CMs to have information technology system. Second, each supplier should be capable of delivering the shipment to the consolidation site within the lead-time requirement. Therefore, the transportation infrastructure from the CM's location to the consolidation site should be carefully evaluated. Third, the delivery lead-time should be reliable and consistent. This requires that CM be strong in production planning and scheduling. More important, aside from the costs effective, CM should consider the reliability and flexibility of transport mode and service in the local delivery.

3, Select the service providers.

Basically, there are three types of service providers to be selected for inbound consolidation: large state-owned-enterprises (SOE), medium-sized domestic enterprises and foreign logistics providers.

Large SOEs such as Sinotrans, COSCO, China Rail and China Post have massive asset positions, broad national network, and strong relationships with traditional SOE manufacturers and other local enterprises. They can provide basic transportation service at competitive prices. However, their ability to offer value-added services in a cost-effective and efficient way is limited.

Medium-sized domestic service providers are mostly privately owned. They have no asset base but are trying to piece together transportation and logistics solutions for specific industries. Compared with large SOEs, they offer better service quality.
Foreign logistics providers have strong international customers networks and international customs relationships. They are now actively expanding in China after obtaining key licenses for logistics operation in China.

There are two considerations for inbound consolidation. First, the service provider must have highly quality management system for coordinating the complex information and goods flow. This includes efficient information exchange with each party and the capability of tracking each shipment. It is obvious that foreign logistics providers are superior to local players in this area. Second, service providers should have local and international transportation network. SOEs and other local players have existing advantages in local transportation network. However, foreign logistics providers are catching up by quick expansion and alliance with local players.

4, Choose consolidation strategies

Consolidation strategy is the synthesis of the consolidation components. With the great range of options available shown in figure 4-2, the strategy answers the question of what is the most cost-efficient way to put together the inventory, vehicle and terminal pieces, without sacrificing service quality. Companies must assess the goods flow patterns, transportation and inventory holding charges and the time value of freight to decide the number of manufacturers and OEM plants in the system, consolidation forms, and shipment release strategies.
One key issue in the international inbound consolidation strategy is the proper location of the consolidation terminal on foreign soils. This issue is complex in China, especially when considering the pace of growth and change within the nation.

Table 4-1: Percentage comparison of economic development and international trade in regions

<table>
<thead>
<tr>
<th></th>
<th>West</th>
<th>Middle</th>
<th>East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Area</td>
<td>71.50%</td>
<td>17.40%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Population</td>
<td>28.50%</td>
<td>33.20%</td>
<td>37.30%</td>
</tr>
<tr>
<td>GDP</td>
<td>17.00%</td>
<td>25.20%</td>
<td>57.80%</td>
</tr>
<tr>
<td>Import/Export</td>
<td>3.30%</td>
<td>4.20%</td>
<td>92.50%</td>
</tr>
</tbody>
</table>

Source: based on data of National Bureau of Statistics of China
Most of the country’s production capacity for export goods is located in several provinces and municipal cities in east coastal regions. These areas are China’s most developed regions including Guangdong, Zhejiang, Jiangsu, Fujian, and the cities of Shanghai, Beijing and Tianjin. East coastal regions dominate international trade and economic development, as illustrated in table 4-1. Cargo movement and industry output are highly concentrated in these areas, the country’s top 8 ocean ports are located here, and its cities are well connected by road networks. Therefore, major cities in coastal areas, which are always the hubs for current transportation network, are the best choices of consolidation points for US companies’ inbound consolidation. However, companies have to pay close attention to the inland cities such as Wuhan, Chongqing, and Chengdu. These cities should be on the shortlist of the best consolidation places in the next 10 years. They are the planned hubs of future transportation networks. More important, these cities’ geographical locations have given them huge advantages in the country’s Western Development policy.

The Chinese government initiated China’s Western Development in 2000. This is a policy to boost its underdeveloped western regions. It covers 6 provinces (Gansu, Guozhou, Qinghai, Shaanxi, Sichuan, Yunnan), 5 autonomous regions (Guangxi, Inner Mongolia, Ningxia, Tibet, Xingjian) and 1 municipality (Chongqing). The main components of the strategy include the development of infrastructure and enticement of foreign investment. More and more enterprises are moving west to take advantage of the region’s unique natural resources, cheap labor and preferential policies, particularly on taxes, land usage and financing. According to Xinhua News (Improved Infrastructure Boosts China’s Western Development, 2005), China has attracted about US$10 billion of investment with an average growth rate of 20 percent since 2000 when China launched going-west strategy, said Deng Zhan, deputy director general of foreign
investment administration under the Ministry of Commerce. Nearly 100 of the top 500 global companies have branched into this region. 2,000 foreign-funded enterprises set up business in western region. China has invested more than 850 billion Yuan (US$102 billion) on 60 key projects of road, airports, rail lines and pipelines along with power stations, environmental controls, and broadband installation. Therefore, with the moving of production capacity to western regions and transportation infrastructure upgrade in these areas, US OEMs should evaluate the impacts on the international consolidation strategy and the possibility of moving consolidation site to hinterland. When companies found that moving their goods into and out of inland China as efficient and cost-effectively as in coastal areas, it will be time to locate their inbound consolidation site to these inland cities by taking advantage of lower labor cost.

Moreover, one more place should be evaluated when deciding where to set up consolidation terminals: Bonded Logistics Parks. The Chinese government now encourages multinational companies to use Bonded Logistics Parks as hubs of international transportation and international sourcing, supplying goods to overseas markets, regional markets and the China market. With the advantages in incentive logistics policies, fast-track export process, these Bonded Logistics Parks can be considered for the consolidation terminal in China.

Another consideration is the impact from fast growing transportation infrastructure. The huge investment in upgrading the transportation infrastructure will lead to an efficient national transport network. Consolidation terminals will no longer be restricted to current hubs of transportation networks, which are always major cities in coastal areas. Companies can have more freedom to choose the location of terminal to best cover the suppliers and products. Moreover, the efficient transport networks might ultimately lead to national consolidation
terminal, which is infeasible because of bottleneck and unreliability in current transportation network.

5 Evaluate the impacts.

The impact of inbound transportation consolidation on the whole supply chain should be examined. The consolidation strategy balances the consolidation benefits of lower transportation costs with the consolidation penalties of potential increased inventory holding costs, longer lead time and added terminal operating costs. Aside from these quantitative indicators such as cost savings, transit time and reliability of transit time, companies should have a qualitative view on the impact of inbound consolidation on the whole supply chain. For example, a cost-effective inbound consolidation may be too rigid to meet flexibility needs in the build-to-order supply chain, and not every party in the existing supply chain might support a shift to a long-term focus and increased level of coordination. Moreover, a company may be locked in to one logistics service provider because of integrated operations between them.
Case Analysis for Tyco International

Tyco is a $40 B manufacturing conglomerate and organized in four business segments: Fire and Security; Electronics; Healthcare; Engineered Products and Services. Most of the business segments use contract manufacturing plants in China for a significant portion of their products. Each business segment or each plant typically coordinates its own transportation from China to the ultimate US destinations, as shown in figure 5-1. This is highly inefficient and sub-optimal, leaving more efficient inbound logistics as a way to achieve further savings. One challenge that Tyco faces is how to use international inbound transportation consolidation to leverage potential synergies between these disparate business units.

Figure 5-1: Flows of goods between China and US
Analysis of product and contract manufacturers location

Currently, the Fire & Security and Engineered Products business segments have about 40-50 Chinese contract manufacturing plants that produce sprinklers, valves and controls, actuators and other industrial products. As shown in Table 5-1, there are many small shipments from China ports, especially from Xiamen, Shanghai, Dalian and Ningbo. For example, the average shipment is below 5 cubic meters. This offers transportation savings opportunity to consolidate these small shipments.
Table 5-1: Statistics of LCL shipment July –August 2005

CBM: Cubic Meter

<table>
<thead>
<tr>
<th>Dept. Port</th>
<th>Total CBM</th>
<th>CBM per shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalian</td>
<td>90.6</td>
<td>7.0</td>
</tr>
<tr>
<td>Ningbo</td>
<td>78.9</td>
<td>9.9</td>
</tr>
<tr>
<td>Shanghai</td>
<td>96.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>33.9</td>
<td>11.3</td>
</tr>
<tr>
<td>Qingdao</td>
<td>357.4</td>
<td>35.7</td>
</tr>
<tr>
<td>Tianjin</td>
<td>128.8</td>
<td>10.7</td>
</tr>
<tr>
<td>Xiamen</td>
<td>115.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Most of Tyco’s contract manufacturers (CM) are located in coastal areas of North China, Central China, and South China. The goods flow from these CMs is illustrated in Figure 5-2. In North China, CMs are located at Shenyang, Dalian, Qingdao and Tianjin. Current exporting ports are Dalian, Qingdao and Tianjin. In Central China, most of CMs are concentrated in Yangtze Delta area and located at Nanjing, Wuxi, Suzhou, and Hangzhou. They use Shanghai and Ningbo as exporting port. In South China, CMs are located in Guangdong and Fujian and exporting shipment from Shenzhen and Xiamen.

As far as current shipping volume and geographical location of CMs, it is obvious that Tyco can leverage on the benefits of inbound consolidation, especially in Central China. For example, Tyco can choose Shanghai as consolidation site for the shipments from suppliers located at Yangtze River Delta. Shanghai enjoys a developed inland transportation network. A comprehensive transportation networks connecting Yangtze Delta including Jiangsu and Zhejiang. Starting from Shanghai, it takes only 4 hours to reach any cities in Yangtze Delta. Shanghai’s airfreight volume ranked the first in China. In domestic air routes, Shanghai has flights with all the provinces. In the field of ocean transportation, Shanghai port has established
shipping and trading connections with more than 600 shipping companies and 500 major ports around the world.

Figure 5-2: Current export goods flow of TYCO CMs in North, Central and South China

North China
Exporting Ports: Tianjin, Dalian and Qingdao

Yangtze Delta in Central China
Exporting Ports: Shanghai, Ningbo

South China
Exporting Ports: Shenzhen and Xiamen
Consolidation strategy recommendation

Merge-in-transit is considered to be a good consolidation model for manufacturers that use contract manufacturing plants in China for a significant portion of their products. Merge-in-Transit refers to a process of consolidating multiple component-shipments from several suppliers into one final customer delivery to fulfill one customer order (McLeod, 1999). Merge-in-Transit is a kind of terminal consolidation that identifies all component shipments in a single order in the consolidation terminal and ensures that these component shipments will be delivered at once. The reasons for Tyco to use this potential model are as follows:

- Products from Tyco’s CMs are high value and stable in demand; so Merge-in-Transit is a consolidation model that can minimize pipeline inventory.

- Current shipment sizes are small and cycle time requirements are stringent. In all consolidation models, Merge-in-Transit can improve service level by reducing the transit time from customer order receipt to shipment delivery.

- Tyco’s CMs are located in the hubs of the current China’s transportation network. This can ensure the reliability of transit time of pickup and delivery from CMs to consolidation site, which is required by the Merge-in-Transit model.

- Service providers, such as DHL, KUEHNE & NAGEL, is capable of coordinating the complicated information and materials flows in Merge-in-transit.
• Consolidation handling costs are relatively low in China.

Merge-in-transit is not a new concept. However, because of global sourcing and build-to-order production, merge-in-transit is being adopted by more and more manufacturers. Companies that have been reported to utilizing merge-in-transit include Hewlett Packard, Dell, Cisco, and Ikea. In the merge-in-transit model, the shipments are first delivered to a consolidation point in China. And the consolidated shipment is then shipped to the customer as a single delivery. This is shown in figure 5-3

Figure 5-3: Flow of goods in merge-in-transit scenario

CM: Contract Manufacturer, OEM: Original Equipment Manufacturer.

The cost savings from merge-in-transit come primarily from 1) reduced inbound transportation costs because of shipment consolidation and 2) reduced distribution logistics costs at the customer by reducing deliveries per order. The cost benefits in merge-in-transit also come from reducing the operational and inventory carrying costs of warehouses and distribution centers. If these savings outweigh the costs of consolidation operations, merge-in-transit is worth considering. Moreover, except for costs saving opportunities and service level commitment,
companies should also examine delivery time reliability from contract manufacturers and service providers’ capability to implement merge-in-transit.

Change to Merge-in-transit consolidation model can affect the distribution of the transportation costs. The activities needed for the merger in transit increase costs in the chain, but the easier handling later in the supply chain provide the costs savings. Investment has to be made to information processing system and deploying the physical consolidation process. Moreover, the relationship between logistics service providers and manufacturers needs to be escalated.
6 Conclusion

The paper began by discussing the reasons for inbound freight consolidation and the methods for doing so. Manufacturers should use the combination of consolidation methods and shipment release policies to decide best consolidation form for their products and suppliers. A number of exogenous factors can affect the performance of inbound freight consolidation such as demand pattern, cost value of shipments, quantity discount and freight spread. While it is clear that international inbound freight consolidation can reduce transportation costs, the decision is complicated by the factor that transportation savings can influence on other links in the whole supply chain system, such as the balance between inventory costs, transportation costs and customer service levels, the influence on the flexibility and vulnerability of the whole supply chain, and the partnership escalation between the supply chain participants.

Another complicating factor for US OEMs to determine the inbound transportation consolidation strategy for goods from Chinese CMs is the fact that it operates in a dynamic environment. Rapid developing transportation infrastructure and constraints of current transportation service two main areas that impact on the success of inbound freight consolidation strategy. Moreover, the deregulation of logistics industry and introduction of Logistics Bonded Part can also influence the consolidation decision.
Therefore, the framework is recommended to US manufacturers after considering the consolidation principles and China’s fast-evolving logistics industry. US manufacturers can use this framework to guide their decision-making. The paper also uses this framework to analyze the saving opportunity in inbound transportation for Tyco’s contract manufacturing in China.

Future studies need to be done in the area of the collaboration between international inbound transportation consolidation and outbound transportation. This is a further step towards the collaboration and optimization of the procurement, production and transportation and inventory control in the global supply chain network.
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