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Chapter 13

Dynamic Models of Transportation Operations

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A manufacturing supply chain can be viewed as a sequence of steps consisting of the modification of a resource at a point (manufacturing) followed by the transfer of the product over space (transportation). Transportation arises because of the spatial distribution of resources, skill sets, and customers. The challenge we face is completing this component of the supply chain efficiently, reliably, and in the case of common carriers, profitably.

It is useful to contrast 'transportation planning' as it is practiced in the context of moving people versus freight. Airlines, passenger trains, and bus companies typically run fixed schedules over fixed routes that are planned months, if not a year, in advance. People are typically able to adjust their travel plans around a fixed schedule, and it is extremely important that the provision of the transportation service be almost perfectly predictable. By contrast, freight operations are highly dynamic, responding to the demands of the market place and the production processes that serve this market. This is not to say that planning problems are not important. Freight companies have to plan the location of terminals, and they will plan operations to a degree, although these tend to be modified on a day-to-day basis.

Our presentation focuses on the issues that arise in the dynamics of real-time operations. We do this in part because dynamic information processes are a key characteristic of freight transportation systems, and also because the literature on static models is relatively much more mature. For a recent and thorough review of planning models for freight transportation and logistics, an excellent reference is Crainic and Laporte (1997). Other important references include Bodin, Golden, Assad and Ball (1983), Fisher (1995), and Desrosiers, Solomon and Soumis (1995) for vehicle routing; Haghani (1989), Glickman and Sherali (1985), and Crainic, Ferland and Rousseau (1984) for rail transportation; Brown, Graves and Ronen (1987) for ocean transportation; and Crainic and

Roy (1992) and Powell (1986a) for less-than-truckload trucking. General discussions of modeling freight transportation systems can be found in Crainic and Roy (1988) and Crainic and Rousseau (1988).

Three key classes of decisions control transportation companies: physical (how to move the product), financial (how to price it), and informational (what information should be provided to manage the system). Of course, the greatest complexity in transportation and logistics is the complexity of the physical processes, which as a result occupies most of our attention. We can use these three dimensions to briefly summarize the characteristics of transportation that make it hard:

(1) Physical: The objects that we are managing:

- Reusable resources: Classical models of the transportation function, when done from the perspective of the shipper, simply have a cost for moving product from one location to another. From the perspective of the transportation company, this activity is done with reusable resources: drivers, tractors, and trailers, for example. Thus, serving a customer request (to move freight from one location to the next) has the effect of changing the state of the system.
- Resource layering: Serving a customer request may require one or more resource classes, which are combined to get the job done. For example, moving a truckload of freight requires a driver, tractor, and trailer. Combining different resource classes is called *layering* and it has the effect of creating complex interactions between resource classes.

(2) Financial: In this dimension, we focus purely on pricing:

- Contract pricing: Given the challenges of the physical process, it is necessary to price a transportation service correctly. The pricing of transportation services are complicated by network effects (sharing resources among different markets), consolidation (sharing space on the same vehicle), and the practice of paying only for the service received, while expecting the resources to be available on demand.
- Static pricing: These would be standard prices a carrier would use for moving freight between a pair of regions (sometimes called traffic lanes). These are market rates (i.e., they are not specific to a contract) that are set in advance. These are generally the highest rates a carrier will quote.
- Spot pricing: In some cases, a customer is willing to pay for a service when requested. A carrier has to be able to quote the right price for this request. Spot pricing needs to account for the state of the system, as it now exists, and the impact the activity will have on the system (the cost of the decision).