Optimization and Analytics Business Opportunities in Liner Shipping

The opportunities (ie. solutions not in use today) are ordered from strategic to operational. Business value is considered in the end of the document. Document starts with a brief background on liner shipping.

Linershipping in a nutshell

A liner shipper operates a fleet of containerships, some typically owned by the liner shipper, other rented (chartered vessels). The vessels sail on the major trade paths in the world: Asia – EU, Asia – North America, EU – North America, South America – North America, South America – EU, etc.

The vessels are organized as city buses, ie, a number of vessels sail on a closed loop (called a service) between a number of ports typically connecting two major trade regions. The vessels are usually separated by one week sail time so that each port is visited according to a fixed weekly schedule. Services requiring very large vessels often are shared by two or more liner shippers. In such vessel sharing agreements (VSAs) each contributing company gets the right to sail a certain volume of cargo on the service on the partner's vessels. The set of services forms the service network of a liner shipper. The name of the game for a liner shipper is to design the network and get long and short term cargo bookings such that the capacity of the network is fully utilized with highest rate cargo.

Network design

Challenge: The global network is re-designed with a yearly frequency (however, the design includes well-known seasonality in the cargo causing some services to exist only in certain periods of the year). The liner shipper has some reasonable estimates of the expected amount of cargo in each port, but it is very difficult to design services that as efficient as possible transport this cargo to its destinations. In particular, some ports may not accept the call window in a network design proposal. This may cause rippling effects affecting most of the design. In practice, it is a demanding iterative process.

Opportunity: develop decision support tools that automates or semi-automates the creation of near optimal networks, so the network group is able to make many different designs to resolve the limitations of call windows.

Revenue management

Challenge: in the daily operation of the network say between two major trade regions, a snapshot of the network has vessels sailing at a certain geographical position stowed with cargo in a certain way and cargo booked at ports or in the process of being booked (booking sales). The question is now, how to price the cargo that fits into the residual capacity between the two regions. This would be easy, if the residual capacity is well known. Ie as in the aviation industry, where the number of empty seats is your residual. For a containership, the number of empty slots is not your residual. They may be impossible to fill or only fillable in certain ways due to complex stowage rules and seaworthiness / security requirements of the vessel. For that reason, the liner shipping industry so far gave up on dynamic pricing. Instead, they use fixed rates and try to route the cargo such that it is split according to its best usage as decided in the yearly design. This is inefficient and inflexible, since the current cargo and booking situation seldom fit with the expectations the network was designed for at the year start.

Opportunity: the cargo flow is a simple multi commodity flow problem. The trick is to constrain paths in the graph corresponding to the voyage of a single vessel with a simplified stowage model of the vessel. The industry applies the flow graphs today, but do not know about the stowage constraints, which makes their current systems weak. But if you have the vessel data (cellular structure and hydrostatic tables) from its loading computer this is not hard to do, given that you know the constraints of container vessel stowage.

Uptake management

Challenge: if we forget about introducing dynamic pricing and stay with fixed rates of cargo (ie. the current situation), we are down to trying to control the sale of bookings of cargo to each vessel in the network. As uptake manager, you are responsible for filling the vessels on a number of services with cargo. You do this pretty ad hoc. You take a look at what is currently on the vessel, how much cargo is currently booked for the next ports, and when the vessel will call these ports. You then play around with a big excel sheet showing the last say two years history of the service. What you are trying to figure out is how much capacity you have left on the vessel and how much cargo there typically will end up to load in each port the vessel calls. You will try to find a situation that looks like the one you have and then assume that history more or less will repeat. Having that in place, you control the booking sale of cargo to the vessel by allowing and disallowing the sale of certain types of cargo and the amounts. The problem is that history seldom repeats and that you neither have a good feel for the free capacity of the vessel nor the cargo to expect in the next ports.

Opportunity: With a stowage optimization model in place, it's possible to calculate the residual capacity of the vessel rather than guessing it. Next, apply machine learning to make accurate cargo forecasts. The latter has at least three challenges: 1) knowing the current bookings often is a strong predictor for future cargo, but the liner shipping industry unfortunately has a tradition of not charging a fee if booked cargo does not show up in the port. Such downfall of no-shows can in certain ports be 50%; 2) you only know the bookings of your own cargo. If you are in a VSA, you may not know bookings of 80% of the cargo; 3) the training data for predicting the forecast must include a booking trend for each port, i.e.: X days before calling port Y, there were M bookings of type T, but on the day the vessel called the port there were only A containers of type T to load. Unfortunately, the liner shipping companies do not save these trends in their databases, only the final load.

Service management

Challenge: today it is hard to say if a particular vessel fits well to the expected cargo to transport on the closed loop of a particular service. It is also had to say whether omitting a certain port would make the service more profitable or not. Answering these questions require that it is possible to calculate the optimal stowage of the vessel over all the ports in a service.

Opportunity: apply stowage optimization algorithms for this purpose and develop decision support applications around the service management use case.

Stowage planning

Challenge: stowage planning is the operational problem of fitting as much cargo on the vessel in each port of call. There is myriad of objectives that work against each other and interfering constraints that a human planner using a computer support tool can spent 4-5 hours of container tetris for just making a single plan. They often know that they could do better, but are out of time. A particular complexity is the lack of accurate cargo forecasts as described above. This means that the planners must apply all kinds of heuristics to "keep the doors open" for unknown future cargo.

Opportunity: apply stowage optimization algorithms to support the stowage process such that the plan quality (intake, flexibility etc.) increases. Use machine learning as described above to improve the cargo forecasts. This will allow multi-port stowage optimization, which today hardly makes sense.

Business value

For a liner shipper with 8% of the world marked some years ago, applying stowage optimization algorithms in the stowage planning process was estimated to at least improve intake by 0.5 percent in grand average. This amounted to 200M euro per year. Optimization at higher strategic levels such as network design and cargo flow management can have much higher impact.