# Efficiency of maritime transport
# A system approach from the logistics perspective

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About 80 % of global trade as well as 40 % of EU domestic trade is seaborne. This results from the fact that shipping is an inexpensive transport mode and able to transport large quantities of goods over long distances. However, shipping is relatively slow and its flexibility is usually restricted to the ocean and existing ports (Schieck, 2009, p.177). Current developments for maritime transport can be described by tightening security requirements, increasing ecological regulations and a high productivity which is necessary to compete successfully.

*Maritime logistics* plans, designs, carries out and controls material and information flows within the maritime transport chain between ports via ships. Typically, also the hinterland connection is included. Therefore, the logistics perspective of maritime transport comprises three sections: pre-carriage, carriage and on-carriage. Pre-carriage and on-carriage influence the efficiency of maritime transport by providing cargo at a port respectively by collecting cargo from a port. However, the central section of maritime transport is the carriage which refers to shipping cargo from the port of departure to the port of arrival. Essential elements of the carriage are

- ships,
- routes and
- ports.

These three elements need to be considered if the *efficiency of maritime transport* is investigated.

Efficiency in general can be considered as the ratio of input and output. Following Pfohl (2010), logistics systems are called efficient if logistics costs (input) and logistics services (output) are included in the system's design objectives. Thereby, both objectives cost reduction as well as service maximization need to be balanced.

**Ships**

There are 4,850 container ships worldwide larger than 100 TEU. They provide a total capacity of 14,300,000 TEU (BRS Alphaliner, 2011). The size of container ships as well as the capacity of the worldwide fleet increase constantly. Efficiency of maritime transport strongly depends on the ships used. Thereby, a number of technical and operational efficiency measures for ships are possible. Increasing ship capacity, for example, leads to decreasing costs per transported container due to economies of scale. Most technical measures focus on propulsion systems (e. g. diesel-electric pod propulsion, use of wind energy) or ship design (e. g. propeller, rudder and hull design). Slow steaming as an operational measure can also contribute to reduce fuel use significantly. Following Cariou (2010), a speed reduction of 10 % implies 10-15 % less $CO_2$ emissions.

**Routes**

1,024 potential liner routes exist between 32 coastal regions (Stopford, 2009). The selected route strongly determines the covered distances and therefore the journey time and cost for fuel. If the selected route is adjusted to weather and ocean conditions (weather routing) the efficiency of the transport can be increased by using favorable currents and winds. Expanding and deepening existing canals (respectively building new canals) provides shorter routes for large ships. As the sea ice in the Arctic keeps melting due to global warming, alternative routes as the Northwest and the Northeast Passage become realistic routes for merchant shipping. This offers shorter distances (appr. 25 % depending on the destinations). These alternative routes are especially relevant for raw material and specialized transports and less for container shipping. However, efficiency of these routes has to be analyzed critically as they are only accessible in summer and administrative barriers reduce cost efficiency despite remarkable fuel savings (El-Sharif, 2009).

**Ports**

There are 400 container terminals worldwide with a significant throughput. The 20 largest terminals have a market share of 50 % (Stopford, 2009). If ports increase their own efficiency they can offer more efficient services to shipping companies. Port efficiency can be influenced in various ways. Fast and reliable terminal and handling processes minimize loading and unloading times and therefore reduce inefficient idle time of ships in ports. Therefore, various measures can be taken to optimize terminal operations like e. g. planning of efficiency infrastructure, intelligent container stacking and fast operating quay cranes. Furthermore, increasing the degree of automation increases reliability and reduces costs.

All efficiency measures for the single elements ship, route and port influence – intendedly or accidently – the other elements' efficiency. These *interactions and effects* need to be considered when the efficiency of maritime transport is enhanced. The increase of ships' sizes, for example, affects the range of ports which can be called at. Due to their draft, the largest container ships (18,000 TEU) can only call at few ports around the world of which none is located in the US. Therefore, ports' waterways have to deepened. However, also larger and more cranes are needed and the hinterland connection has to be optimized to ensure that containers can be transported without delay out of the terminal area with limited storage space. Furthermore, terminal processes have to be adapted as more containers arrive at the same time in order to keep lay days as short as possible. However, also routes are affected by larger ships' sizes. With the present lock chambers' dimensions, the Panama Canal can be passed only by ships with a maximum beam of 32m, a length of less than 294m, and a maximum draft of 12m which correlates to a 5,000 TEU container ship. Thus, certain ships cannot be used for a route passing the Panama Canal resulting in increased travel time (as a detour has to be made) or higher fuel use (as e.g. two 5,000 TEU ships have to be used instead of one 10,000 TEU ship).

*Another example of interactions between efficiency measures* can be explained on the basis of the Northeast respectively Northwest Passage. If the northern routes are used, the traveled distances reduce significantly. This implies fuel savings along with increasing cost efficiency. However, ships have to fulfill certain requirements for shipping in the Arctic. For example, the hull and especially the bow have to fulfill the requirements for a higher ice-breaker category. This influences the ship's shape and therefore its fuel efficiency. The alternative routes also influence ports as some ports in countries bordering the Arctic might gain cargo volume.
These examples show that if the efficiency of one element of the ship-route-port-system is analyzed, the other elements need to be considered as well in order to avoid negative effects on the overall efficiency of maritime transport. Applied research in the field of logistics develops – amongst others – simulation tools to analyze and increase efficiency of logistics systems. Thereby, simulation provides options to test different scenarios before implementing them. In maritime logistics, various simulation and also visualization tools exist:

- Process simulation software to analyze terminal operations
- Ship simulators to practice and test ship navigation on sea and in ports
- Planning table to plan and visualize terminal design solutions.

Recent research aims to connect these tools in order to provide a holistic approach to efficiency of maritime transport.

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