TECHNOLOGICAL INNOVATIONS IN TRANSPORT INDUSTRY

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Abstract Current situation stipulates growing requirements to the efficiency of economic subjects' performance. Big potential in this direction lies in the rationalization of logistical functions of organization, like: transportation, warehousing, interfunctional and interorganizational coordination, etc. One of the possible ways to rationalize firms' performance, without any doubt, is industry leaders' best practices application. However, to switch from the role of the follower to the leader it is essential for the organization to foresee future trends, including the field of effective flow management (logistics). Logistical technologies development was considered as an object of current paper: its main trends analysis and description of technological innovations that have resulted in decreasing of logistical costs in the goods shop cost in the last few decades were investigated. Also author has made a try to perform qualimetric analysis of the logistics technologies under consideration, i.e. to investigate dynamics of characterizing features of the analyzed object with the potential possibility to use these parameters for forecasting of future development trends. Problems of effective operation of two transport types (air and marine) and of several variants of transport-logistical delivery schemes (combined, container, tanker) were covered in the paper, inter alia following technological innovations were analyzed: jet engine invention, containerization and tanker shipments.

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1. JET ENGINE

In accordance with the estimates of International Air Transport Association (International Air Transport Association, 2007) approximately 320 million people are using air transport for business trips annually; 35% of global trade value ($12 trillion in 2006) is delivered by air. All these became possible thanks to jet engine – perhaps, the most substantial innovation in the long distance transportation sphere of the last time. Jet engine is easier to maintain, safer, more fuel-effective comparably to propeller engine and more suitable for long distance travelling. Since its invention in 1960-s the progress in this direction and the whole aviation industry is firmly associated with the notion “jet engine”.

However, like with other revolutionary inventions in transportation technologies, it took time from the spontaneous scientific discovery to worldwide expansion. Frank Whittle (UK) in 1929 and German physicist Hans von Ohain in 1933 are commonly known as inventors of jet engine who independently developed jet propulsion concept. Jet engine technology has been progressing very fast after World War II. Real breakthrough in civil transportation sphere has become the launch of jet engine based airplanes Boeing 707 and Douglas DC-8: before their launch jet airplanes were noisier and had bigger operating costs comparably to most advanced propeller engine aircrafts. The only competitive advantages of jet aircrafts of those times were speed and bigger seating capacity. But since the beginning of 1960-s technological improvements in the sphere of jet aeronautical engineering (invention of so called bypass turbojet engine) have led to the end of propeller engine age in the long-distance transportation: during 5 years tone-kilometer price has decreased by 40%. Jet aircrafts have higher power to mass ratio comparably to propeller engine airplanes which allow them perform longer distance flights faster and with bigger payload capacity. Air transport speed dynamics is shown on Fig. 1.

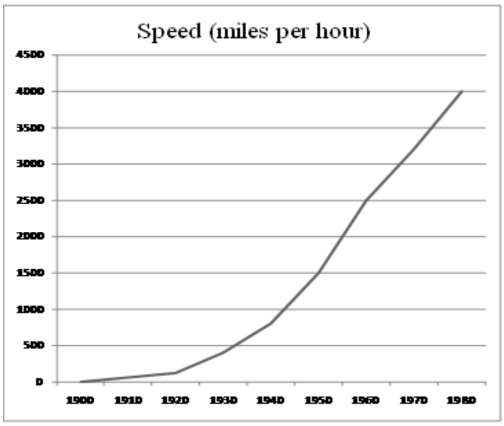

Fig. 1 Air transport speed dynamics

Higher quality and low operating costs have a big impact on the development of various world economy industries. Let's consider some of the implications of widespread expansion of jet propulsion aircrafts.

- Maintenance of long-distance supply network between customers and sellers. In terms of volume world trade is mostly processed via marine transportation, but airfreight has took its important niche in production systems based on "just in time" concept. For the general cargoes shipments traditional marine lines are used, but if the firm is concentrated on speed and accuracy of deliveries or operates with high value/weight ratio goods in their supply chains then it will use airfreight. Even in export-oriented Brazil economy in 2000 air transport was involved in 0.2% of export cargo volume while 19% of its value (Sánchez, Hoffmann, Micco, Pizzolitto, Sgut & Wilmsmeier, 2003, pp. 199–218). Classical examples of industries with wide use of airfreight advantages have become semiconductor manufacturing and fashion industries. Total global quantity of semiconductor shipments has a strong correlation with global airfreight volume and is often considered as a main indicator of industry financial health. Life cycles of fashion industry products has reduced so much that one of Spanish fashion retail chains started direct shipments from factories to outlets, fully changing the shop's product range twice a week in order to meet frequently varying customer preferences (Rohwedder & Johnson, 2008).
- Long-distance transportation of perishable goods ensuring. Relatively cheap and rather regular air traffic allows such countries as Chile, Colombia and Kenya to supply agricultural and horticultural products on the markets of Europe, Middle East, North America. As an example here we can consider Kenya, which nowadays provides 30% of global flower market: flowers cut in the morning are available on the Amsterdam market by evening. Flowers have become one of the main Kenyan export objects (like tourism and tea), which volume in 2007 was estimated $605 million with 1.2 million employed in the industry. Global market antipode of Kenya is Bangladesh, deficit of refrigerant airfreight in which doesn't allow the country to provide high-value fruits and vegetables to the markets of Middle East (Dixie, 2002).
- Mass tourism to developing countries. In 2005 tourism expenditures to developing countries became $200 billion (World Tourism Organization, 2006), what was caused mainly due to relatively cheap air travelling. Wide use of charter flights has a big potential of costs decrease by introduction of a set of additional services. Airport development in main touristic routes results in "growth poles" creation with high level of additional services and specialized labor market provision. Thus, in 1990-2005 number of tourists visiting south Africa grew 8% annually – from 6.8 million to 23.6 million - and touristic expenditures from $4.1 billion to $14.5 billion; China – by 10% annually; Cambodia is now visited by 2 million tourists annually, Vietnam – 4 million, i.e. 16 times more than in 1990.

2. CONTAINERIZATION

Approximately 90% of world non-bulk cargo is moved in containers via road, railroad and marine modes of transport (Ebeling, 2009, pp.8–9). In 2007 more than 18 million containers made more than 200 million movements. Containerization has even changed the performance indicators used to assess capabilities of port system and marine transport services: cargo is currently measured by means of Twenty-, Forty-Equivalent Unit (TEU, FEU). Under TEU is supposed parallelepiped 20 feet length, 8 feet width with maximum gross weight of 24 metric tons.

Containerization originates in the coal-mining regions of England in the end of XVIII century. In 1795 Bejamin Outram has opened Little Eaton Gangway coal extracting from which was performed in metal wagons (Butterley manufactured). These horse-drawn wagons have become containers which loaded with coal were transferred to Derby Canal barges (Ripley, 1993). By the middle of XIX century both wooden and metal containers were transported by railroads of several continents with possibility to move them to other transport modes, in the start of XX century railroads have started to propose piggy-back services (flatcar transportation of cargo in highway trailers without unloading) to their clients.

Revolution in containerization is often associated with New Jersey transport company owner Malcolm McLean who made a very simple conclusion in this field: unpacking of cargo is usually needed only in the points of departure and arrival while reloading and repacking cause sufficient additional costs. In 1955 he together with engineer Keith Tantlinger has developed modern intermodal container. Main problem he wanted to solve was the development of cargo container design which would allow effective loading of container on the board of vessel and safely delivering of cargo to a distant port of destination. Their work resulted in 2.5 mm (0.098 inch) gage corrugated steel parallelepiped of following dimensions: height - 2.4 m (8 feet), width - 2.4 m (8 feet), length – 3 m (10 feet). On the top of each corner the authors have placed twist lock for the safe crane fixing and movement of container. After the work was done Tantlinger has persuaded McLean to share the patented design with the industry – this was the first step for transport container international standardization.

In 1956 McLean has offered the market "land-sea" service on the base of his modified cargo vessel «Ideal-X», which performed voyages from Newark, NJ to Houston, TX with 58 containers on deck. This idea haven't had a big demand for more than 10 years until US military forces had a need for an effective way to transport cargoes to Vietnam. Despite of severe competition McLean was able to sign a contract for the container port construction in Cam Ranh Bay and for transportation of cargoes from California to Vietnam via cargo container ships. Without containerization US military would have faced big problems with provision of 540 000 militaries in 1969.

Japanese government was the first one which espoused the enlargement of containerization concept: in 1966 Council on transport and shipbuilding rationalization has recommended Ministry of transport of Japan to limit excessive standards competition in this area and to benefit from the new technology; this Council also persuaded Japanese government to start construction of container terminals in the territories of Tokyo- Yokogama and Osaka-Kobe – first container crane has started its work already in 1968.

After all necessary logistical infrastructure objects were erected container transportation development has started. By the end of 1968 for the route USA - Japan of 7000 tons cargo volume per month there was a competition between 7 companies, but along with the port and railroad infrastructure development the container shipments volume gradually increased: it has tripled in the USA from 1980 till 2002 from 3.1 million containers to 9.3 million.

With the increase in volumes of container shipments container standards were also increasing: after FEU 48- and 53-feet standards have appeared. Global fleet of cargo container ships is also increasing rapidly: by 10% annually in 2001-2005, - the deadweight of container ships is also on the way: dozens of them were able to handle 4000 FEU already in 2006, the same year the largest container ship «Emma Maersk» (396 m in length), able to transport 14500 TEU was floated off. Nevertheless, there are geographical boundaries and topological limits for the infinite growth of vessels' size: due to Panama Canal gateways size it is not used for pass of container vessels over 5000 TEU, currently it is reconstructed to be able to transmit 12000 TEU vessels; global trade limitation is Strait of Malacca (between Pacific and Indian oceans), which cannot pass vessels over 470 meters length and 60 meters width.

3. TANKER TRANSPORTATION

For the transportation of liquid cargoes in the international trade the transport technology that appeared in the end of XIX century - tankers are mostly used. Before there was no technological possibility to transport fluid cargo in big volume – so as there was no market need to trade with such a kind of goods: liquids were traditionally transported in relatively small casks. Fluid transportation was limited by following obstacles:

- Impermeability: wooden ship's paneling is waterproof not to a sufficient level to avoid liquid's leakages. Development of metal (steel) paneling has solved this problem.
- Loading / unloading and distribution: for the physical movement of liquid the swap by means of some pumping-pipeline system is needed, without development of which tanker transportation would be impossible. Steam engines have found their application in the first pumping systems as on

vessel’s board so as in the port zone, from where cargo was distributed among customers.

- Free Surface Effect: big liquid volume on vessels’ board has a sound impact on its stability, especially in the moment of reaction to the vessels’ movements. This effect is not appearing while handling relatively small volumes of fluid cargo in casks, but is leading to vessels’ turnover with big volumes on board. To solve this problem modern tanker’s capacity is divided into separate blocks.

Tankers have found their first application in the oil industry for the transportation of refined fuel from the petroleum-refining plants to customers. Later on tanker shipment technology became a main mode for other industries, which use liquids as objects of physical distribution. The reason behind tanker’s wide use is obvious economy on big transported volumes of liquids and on its storing at specialized terminals: even famous brewing company Guiness used tankers for stout transportation within Irish Sea. Evidently, different products require different cargo-handling technologies and specialized transport vehicles: among tankers one can differentiate “chemical” for the carriage of dangerous chemicals, “petroleum” (petrol carrier, oiler) – for the crude oil and products of its refining transportation, “LNG-carriers” – for the liquefied natural gas movement. Among oil carriers there is a certain class of supertankers, which are used for petroleum carriage around Horn of Africa (countries of north-eastern Africa: Djibouti, Somali, Sudan and Ethiopia) from Middle East countries. The largest from the ever built (already scrapped in 2010) supertanker was «Seawise Giant»: 458 meters (1503 feet) length and 69 meters (226 feet) width.

Let’s consider the tanker’s classification from the point of their deadweight, developed by Shell-company in association with London Tanker Brokers’ Panel in 1954 and also known as AFRA – Average Freight Rate Assessment. In accordance with AFRA, there are following groups: General Purpose tankers maximum of 25000 tons deadweight; the group of Medium Range tankers includes the ones with 25000-45000 deadweight tons and Large Range – more than 45000 tons. During 1970-s tankers were becoming larger and classification under consideration was enlarged taking into account the “gross ton” (1016.04691 kg) application:

- 10,000–24,999 tons : General Purpose tankers
- 25,000–44,999 tons: Medium Range tankers
- 45,000–79,999 tons: First Large Range tankers (LR1)
- 80,000–159,999 tons: Second Large Range tankers (LR2)
- 160,000–319,999 tons: Very Large Crude Carrier (VLCC)
- 320,000–549,999 tons: Ultra Large Crude Carrier (ULCC)

Additional tanker’s characteristics depending on their class (ability to pass through gateways of largest world canals: Panama, Suez and Malacca) are collected in Table 1.

Table 1 Main characteristics of oil carriers

Class	Length	Beam	Draft	Typical Min DWT	Typical Max DWT
Seawaymax	226 m	24 m	7.92 m	10,000 DWT	60,000 DWT
Panamax	228.6 m	32.3 m	12.6 m	60,000 DWT	80,000 DWT
Aframax	253 m	44.2 m	11.6 m	80,000 DWT	120,000 DWT
Suezmax			16 m	120,000 DWT	200,000 DWT
VLCC (Malaccamax)	470 m	60 m	20 m	200,000 DWT	315,000 DWT
ULCC				320,000 DWT	550,000 DWT

At the moment there are 380 vessels in the world with deadweight 279000-320000 tons, only 7 with deadweight more than 320000 tons and around 90 – with deadweight 220000 – 279000 tons (Chisholm, 2007, pp. 881–889) (Fig. 2).

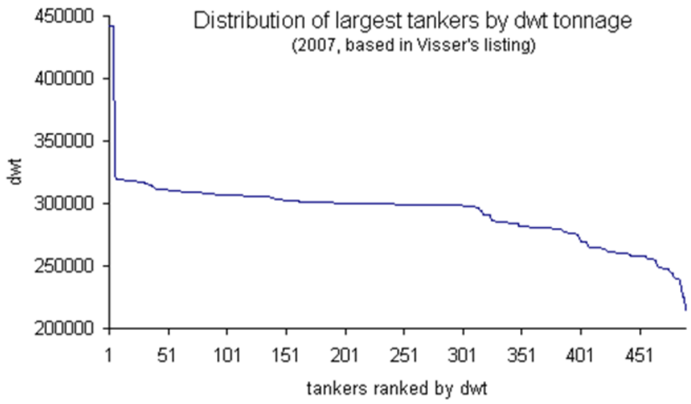

Fig. 2 Distribution of largest tankers by deadweight

It should be specially mentioned that exactly increase of vessels' physical dimensions has lead in historical perspective to a larger decrease of transport tariffs, for instance, relatively to airfreight tariffs, where this trend, although took place, but to a smaller extent. Ad valorem (freight rates dependant on cargo value) tariffs dynamics for airfreight and sea freight is shown on Fig. 3 (Hummels, Lugovskyy & Skiba, 2007) it's obvious that sea tariffs were decreasing faster than air ones

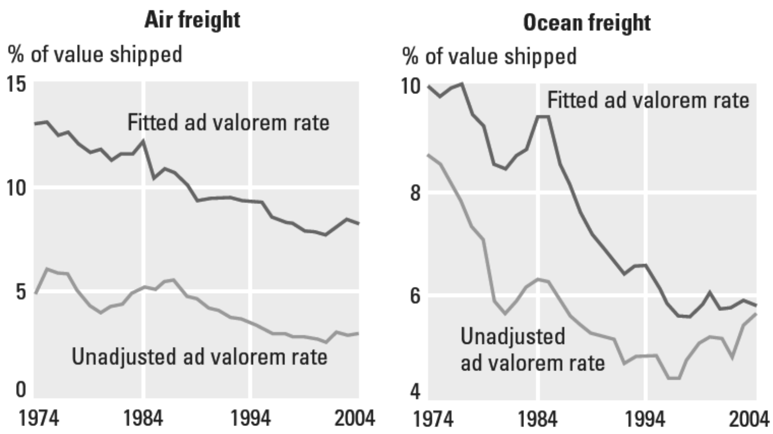

Fig. 3 Ad valorem freight rate on sea and air transport dynamics from 1974 to 2004

To resume it can be argued that technological innovations have a big impact on logistics costs decrease what was shown by current investigation. Also parameters being improved (speed, capacity, costs) due to such innovations can be considered as very perspective qualimetric parameters for the logistical objects (transport, warehouse, IT) development forecasting purposes.

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