Theory of shipping productivity revisited: Industrial revolution, ship technology and shipping freight rates

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Abstract

This paper reviews theories on shipping freight market in the period of 18th, 19th and 20th centuries. Bicentennial fluctuations are indicated in maritime transportation costs and cause of such movements is investigated by many scholars (D. North, 1958; Harley, 1988, 1989 among others). The productivity of shipping transportation is found the most important reason of longstanding freight rate decline between the beginning of 1800s and 1900s. The present research overviews freight rate indices and its outcomes about the boom-bust cycles of shipping costs in the industrial revolution era and afterwards. Several studies investigated dry cargo shipping markets and some of them attempted to construct a composite index of freight rates (Isserlis, 1938; Mohammed & Williamson, 2004; Klovland, 2008 among others). Although, several critiques are indicated about the method of composition, these indices depicted long term movements in general (Veenstra and Dalen, 2008; Mohammed and Williamson, 2004). Theory of shipping productivity is investigated by a long term composite freight index and fluctuations of post-WWI also compared.

Keywords: Shipping costs, Freight index, Transport productivity, Dry cargo shipping.

I. INTRODUCTION

Importance of seaborne trade is indicated by several studies (Metaxas, 1971; North, 1958; Jacks, Meissner and Novy, 2009 among others). Seaborne trade is a value of how much cargo is transported in how much distance between two seaports. Productivity of shipment will be depending on quantity of cargo and navigating distance. These two main items are affected by various factors including economics, politics, geographical boundaries, warfare, weather conditions etc. Increasing stability on global politics trigger trading activities and finally shipping industry steps up to enhance facilities and capacities. On the other hand, seasonal factors may change direction and boost to wider navigating durations and distances (i.e. hurricanes, tsunami). However, productivity changes in the long run are based on more extensive elements of world system. Such an analysis should be performed by a broader perspective which is enriched by all economic, political, technological and historical domains.

One of the critical instruments of this analysis is proper and quality statistics as possible as. In literature of economic history, statistics for shipping volume and transportation costs are presented and investigated by various studies (Isserlis, 1938; North, 1958; Harley, 1988 among others). By the presence of proper data, we explored that shipping played a key role on economic development and reasons of freight rate fluctuations are discussed for understanding such economic interactions and results.

Foreign trade balance is generally based on import and export activities. However, there is an unaccounted item which is the service of overseas transportation (Isserlis, 1938). There is no doubt that shipping is a key indicator in the international trade and its cost is a part of retail prices. Fluctuations on shipping freights still influence prices on finished goods as it is before. The structure and terms of shipping freights are classified on two main divisions which are voyage domain pricing and time domain pricing. Voyage domain pricing named voyage charter is including all fixed and variable costs of shipment such as operation costs, port dues, agency fees, brokerage commissions, financing costs etc. On the other hand, a time domain pricing named time charter only consists of fixed costs such as financing costs, daily mandatory expenses (i.e. manning, victualling). If a trading price of a product is declared as CIF (cost, insurance, freight), it is also reflecting transport cost factor anyhow.

Various shipping companies, exchanges and governmental institutions keep freight rate records and also several freight indices are published for average of the market and for a specific ship size. History of freight rate is investigated by many scholars and the theories on shipping productivity are indicated according to several hypotheses (Harley, 1988; North, 1958; Mohammed and Williamson, 2004). Particularly on long distance transportation, shipping cost is crucial even it was critical on 18th and 19th century's era. Capacity of shipment was highly limited, speed of service is tied to proper seasonal winds and cargo traffic was single way a long time rather than both directions. Under the conditions of the various factors, shipping service evolved and freight rates are broadly affected from the particulars of maritime transportation characteristics.

The present research discusses shipping productivity and compares economic thinkers about their inferences and contributions. From eighteenth to twentieth century, declining freight rates and increasing productivity are

well introduced and accepted widely. However, reasons of such decline of freight rates are discussed in several studies and various theses are concluded. Even Harley (1988) stated that his study overturns the previous work of North (1958).

II. SEMINAL WORKS AND MODERN ECONOMIC APPROACH

2.1 Preliminary works of Leon Isserlis

Leon Isserlis (1938) published his outstanding study "Tramp shipping cargoes and freights" and provided one of the noteworthy sources of freight market fluctuations. As one of the important statistician, he served for Chamber of Shipping, UK and compiled several freight rate data which mainly benefited from Angier (1920). His assessments are pointed out cycles of warfare that are Franco-German War, African War and World War I. Although, Isserlis supplied freight rate index for a critical turning point of the world, these indices are criticised by many scholars because of lack of suitable number of fixtures and unnecessarily overweighting of some routes (Mohammed and Williamson, 2004; Veenstra and Dalen, 2008 among others). Gathering this information with previous records and inferring reasons of longer term fluctuations are remained for contemporary researchers such as North (1958) and Harley (1988).

2.2 Institutional improvement thought of Douglass North

Douglass North (1958) attempted to extend the recent freight market knowledge by superimposing freight rate of British Import and American Export data. According to Douglass North, the decline of freight rates in the nineteenth century was formed by three main factors of shipping productivity: *Increasing efficiency of freight markets*, *Technological innovations* and *Development of external economies*.

The nineteenth century is also crucial in terms of communication technology. Increasing availability and speed of telegraphy facilities ensured proper and timely communication between Shipowners, Charterers and also Masters of ships. Imperfect market condition (Fama) was mitigated and uniformity in the movement of rates was partly maintained.

Another indication is reported with respect to technological improvements. Both steam power usage and metallurgical revolution improved stability for higher carrying capacity ships and rapid service even in the lack of winds for sail propulsion. Resistance for stronger sea conditions is obtained. Hull and engine technologies improved safer navigation and prevented loss of property (i.e. due to piracy attacks).

North (1958) also concluded an important aspect of the post-discovery term of the world which is presence of cargoes for returning to homeports that is named backhaul cargoes. After the industrial revolution, both in North America and Asian destinations, exporting products were supplied and backhaul cargoes could be carried on a highly competitive price as compared with ballast voyages of empty cargo holds. New regions expand in population and income with new export trades and further export products were implemented.

North (1958) extended our knowledge about the long term decline of freight rates in the nineteenth century and the freight rate data is deepened backwards until the beginning of the nineteenth century. Later these data is judged by Harley (1988) because of the technical particulars of cotton loads.

2.3 Technological improvement thought of C. Knick Harley

C. Knick Harley pointed out that the main source of increasing productivity is metallurgical developments which are broadly improved by industrial revolution. His argument supports that technological improvements provided stronger hull designs (i.e. metal ships), increasing capacity of ships, increasing service speeds (i.e. steamship technology) and therefore sea transport ensured productivity gains due to technical performance.

Harley (1988) indicates that North's freight rate data for cotton trades has an important shortcoming since the packaging technique of cotton bags somehow changed. Compressing of cotton into the bags provides additional transport volume and the cost of carriage is lesser per tons of cargo. By this way, capacity reaches to 20-25 pounds per cubic foot from 8-12 pounds per cubic foot. It is almost twice of previous measures. North's evidence for the sharp decline at the beginning of the nineteenth century is arisen mainly by such technical metamorphosis. In spite of a long term moderate decline on the rates, it was not expected deep as indicated for the first half of 1800s.

Harley (1988) summarises reasons of freight rate decline on six items:

1. Innovation of steamships against the sailing ships.
2. Opening of Suez Canal and superiority of steamers on Asia-Europe transport. Larger sailing ships are usually not suitable for Red Sea navigation because of lack of proper winds.
3. Metallurgical technology provided safer ship design, decreasing number of crew, lesser loss of ships, and increasing capacity of cargo space.
4. Increasing productivity on steel industry reinforced shipbuilding industry for cheaper production and stronger and larger designs.
5. Packaging technology ensured increasing use of transport volume.
6. Presence of tugs supported manoeuvrings of larger steamers in the port.

Furthermore, there is an unavoidable factor, “warfare”. The eighteenth century was consisted substantial warfare including War of the Austrian Succession (1740-1748), the Seven Years War (1756-1763), the War of American Independence (1776-1783), and the Wars of the French Revolution and Napoleon (1793-1815). Comparing with the nineteenth century, the eighteenth century had stronger effect of warfare on international trade. Therefore, it was not safe for navigation, and increments for war risks were incurred on the rates of shipping transport.

2.4 Modern contributions

Kaukiainen (2001) reported a research about the transmission of information and influences of electric telegraph. After 1820s, information transfer speed and coverage are broadly developed and communication has been available for intercontinental transmissions too. Increasing distribution of information ensured efficient use of commercial news, meteorological records and port facilities. Thus, circulation of freight rates and nominated cargoes is performed to several points including both sides of Atlantic and Indian trades. “*Communication technology*” is recorded one of the critical reasons of freight rate decline.

O’Rourke and Williamson (2002) examined “*Globalisation*” issue including long history of international trade. About freight market, they pointed out globalisation effect and increasing international trade. By the establishment of free trade and commercial collaboration between various trading routes, increased efficiency of markets provided competitiveness on shipping service.

Jacks (2005) investigated international commodity market integration in the Atlantic economy under the global developments of 19th century. He reported issues concerning price fluctuations and trade costs. An important indication is presented about the freight market. Freight rates are slacked in the 19th century by the increasing bilateral trades among the Europe-America and Europe-Asia routes as well as technological developments. On several centuries, trade flows are characterised by the single direction transport and ballast voyages (empty cargo holds) are steered for backing to product sources. Industrial revolution influenced many countries including developing continents such as Americas and Asia. Manufacturing facilities are developed and products are available for exporting. Merchant ships are loaded on both directions and free spaces are utilised well. “*Bilateral utilisation*” provided reduction on cost of shipping.

III. OVERVIEW OF CONTRIBUTIONS

One of the most cited issue on economic history is the decline of freight rates in the 19th century and its influences on global trade. Although, wholesale prices have increased at the same period, shipping costs distintly exposed a long term decline. Many economic philosophers developed theories about the decline of freight rates and they mainly indicated rise of shipping productivity by several reasons. For building a wide perspective, I want to summarise and extend these theories.

First of all, the political, economic and structural differences between 1700s and 1800s should be defined. Analysis is based on investigation of ’efficiency of freight markets’ and ’technological capability of shipping service facilities’. Although, concentration is on two main issue, one more item should be expressed which is the opening of Suez Canal.

3.1 Efficiency of Freight Markets

About the condition of free trade, Navigation Acts (1660 and 1696) of British Empire have critical importance.

Navigation Acts regulate shipping from and to British states. According to the Acts;

1. Only British ships could transport imported and exported goods from the colonies.
2. The only people who were allowed to trade with the colonies had to be British citizens.
3. Commodities such as sugar, tobacco, and cotton wool which were produced in the colonies could be exported only to British ports.

These regulations restricted flexibility of fleet and discriminated other country fleets. Therefore, available shipping fleet term is different than today. Although, probably there is suitable number of tonnages, supply of shipping service is partly regulated. The case of Navigation Acts continues till the end of 1700s. In the seond half of 18th century, the British have fallen in several warfare and Navigation Acts are loosen. In spite of the official declaration of free trade in 1849, shipping service gained its freedom by the revolutions.

When passing from 18th century to 19th century, one of the critical discrimination of sea trade is collapsed. The effect of Navigation Acts presumably can not be avoided. Notably, Napoleonic Wars dissolved the discrimination and both Atlantic and Levant trades gained competitiveness. Downturn of Ottoman Empire also contributed to release Levant trading routes.

Another important improvement is arisen from the ’Bilateral Trading Pattern’. Particularly in Atlantic case, shipping service is mainly employed on single-way trades from Europe to Americas before 19th century. However, Industrial revolution brought several opportunities for Americas to improve manufacturing activities and external economies contributed to transportation industry. The technological improvements of Industrial revolution (it will be discussed soon on the next section) ensured to produce some backhaul cargoes from

Americas to Europe and from Indies to Europe trades. Ships have chosen to be loaded for backing routes at a competitive price. Freight rates would be balanced on both directions day by day. Marginal discounts existed on long distance shipments.

3.2 Technological Capability of Shipping Service Facilities

By the Industrial Revolution, shipping industry gained productivity through three main track: one of them is the development of steam power on merchant ships, another is the development of steam power on manufacturing industries and the third is metalurgical innovations.

Steam power provided an exclusive superiority and ships were available to navigate safer, rapid and with increasing cargo capacity. It was very valuable for both Atlantic and Indian routes. By the steam powered industries on both sides of Atlantic, ships were loaded for both directions. Manufacturing and export products have been raised in Americas and empty spaces of ships could be loaded with a reasonable low costs. Metalurgical improvement of hulls provided larger, stronger and high capacity merchant fleet. These ships are also less costly about the manning. Rather than a highly specilised sail ship operation, metal steam ships are easy to operate and crew size declined.

Communication technology is another critical improvement which develops efficiency of freigth markets by exchanging commercial information. By the 1800s, port and shipping news were distributed speedy and intercontinental telegraph communication increased competitiveness of negotiations and also both ports and fleet were utilised better.

One of the most fascinating geographical technology should be opening of Suez Canal. In 1869, Suez Canal have began to service for merchant shipping and the canal provided shorter voyages to Indies. However, in the time of opening and later on closure issues of 20th century, effects of Suez canal was not larger than a regular freight rate cycle. Quantitive measures of this issue will be discussed on the next section.

IV. BICENTENNIAL FREIGHT RATE CYCLES AND COMPARATIVE ANALYSIS

A recent study of Duru and Yoshida (2009) provided a long term freight rate index (here-after LFI) by combination of unweighted average growths of several freight rate data. LFI is based on dry cargo and general cargo (before 1950s) shipping records which are mainly derived from various cited papers. LFI series is a long term data (267 years) starting from 1741 and ending to last records. Such a long term record ensures comparative analysis between several centuries. Fig. 1 indicates the LFI dataset and it is clear that there is a two-century cycle in 1700s and 1800s. A hundred-year upturn follows the previous cycle. Supercycle of WWI is well noted.

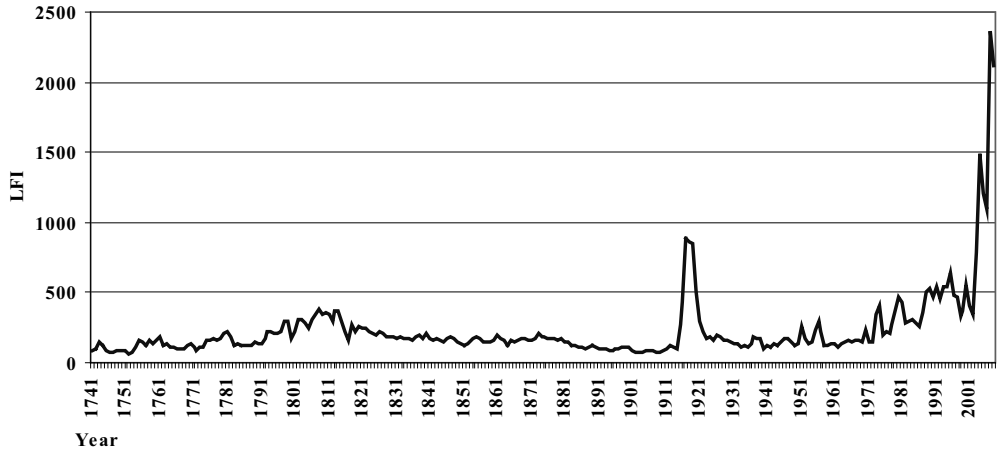

Fig. 1. The LFI series between 1741 and 2008.

18th century have a long term increasing trend and higher volatility relative to 19th century. In the 19th century, a long term decline exists and volatility is broadly damped. Finally, 20th century brings a long term upturn with highly volatile rates. The main concentration of comparative analysis will be between 19th and 20th century. We listed several reasons for the decline of freight rates. However, many similar cases exist in the 20th century and their results are major emphasis.

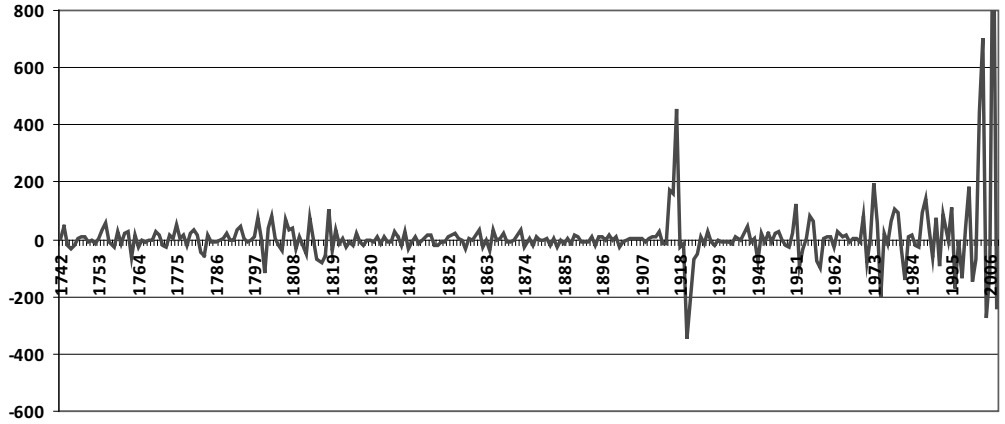

Fig. 2. The first differences of LFI series, d(LFI).

Table 1 points out some important particulars of two centuries. 19th century is the long term downturn period and 20th century is the long term upturn period. The concern is whether conditions are really changed. One of the most noted particulars of 19th century is the technological improvements. Nevertheless, the 20th century recorded the innovation boom which is ever seen. Steam power is displaced by diesel engine, both the size and speed of merchant ships are exponentially increased[1]. Port technologies have also ensured high speed operations.

Table 1. Comparison of innovations between centuries.

Period	1800s	1900s
Trading discriminations	Partly existed and ended by 1849, free trade policy of England.	Negligible
Ship technology	Steam power and metal hull	Diesel engines and higher propulsion power, very large carriers, electronic navigation, automatic cargo handling, satellite communication, higher speed, self-maneuvring by thrusters etc.
Communication	Telegraph	Telephone (although it is invented on the last quarter of 1800s, practically and widely used after 1900s), satellite systems, internet, electronic mails, P2P internet phones.
Trading routes	Multilateral trading.	Multilateral trading. World wide, unlimited trading.
Transport geography	Suez Canal opening.	Various sea canals were constructed including Panama Canal.

However, decline of trade discriminations, communication technology and multi-lateral trading are existed since the 19th century. Especially trade discriminations and multi-lateral trade should be noted as specific improvements of the 19th century. All of these factors are parts of improvement of market efficiency on the shipping transactions. Presumably, the major particulars of the 19th centuries decline on freight rates are based on efficiency of markets. Efficiency is also a part of productivity of merchant fleet because of increasing utilisation.

[1] For a detailed information about shipping technology development, please refer to Stopford (2009) (several pages).

V. CONCLUSION

This paper reviews main theoretical ideas on shipping and productivity of sea service. The long term decline of the 19th century is a spectacular issue, so many scholars investigated the term of decline. Nobel Prize awarded economic historian Douglass North, particularly focused on efficiency issue, but several studies also argued on technology improvements. A broad comparison of circumstances of centuries indicates prominent importance of efficiency rather than technological advances. The 20th century is unique period of technological improvements. Although, technology should have had an important impact on shipping freights, the difference between two periods is mainly derived from globalisation of shipping service.

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